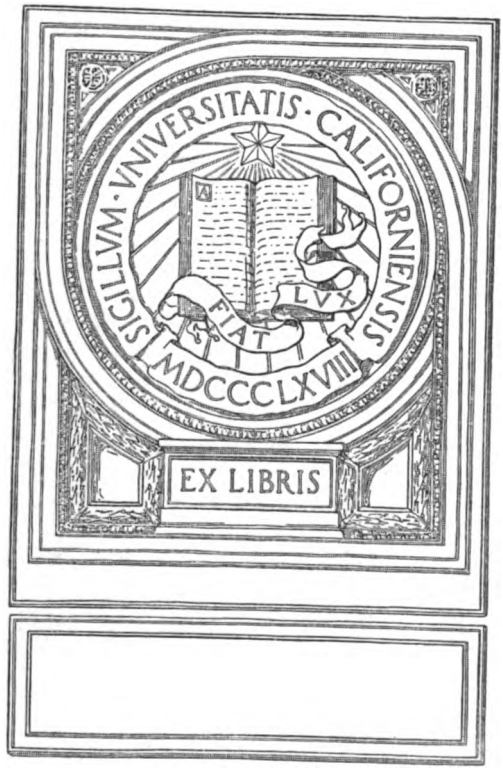

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Doctor Wood

MODERN WIZARD OF THE LABORATORY

The Story of an American Small Boy Who Became the Most Daring and Original Experimental Physicist of Our Day—but Never Grew Up

BY WILLIAM SEABROOK

HARCOURT, BRACE AND COMPANY, NEW YORK

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first edition

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To

GERTRUDE WOOD

Without her help this book
could never have existed,
nor for that matter could
Robert Williams Wood
himself—for long

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FOREWORD

Concerning American Small Boys and American Giants

AMERICAN small boys love to invent and make things—gadgets, smells, kites, explosions, slingshots, little engines, and beanshooters. They also love to play outrageous pranks.

The essence of Robert Williams Wood is that he is a super-endowed American small boy—who has never grown up. The same was true of Mark Twain both as a person and as projected in the personalities of Tom Sawyer and Huck Finn. The part played by environment in the development of these two American small boys (one living and one dead) who stand and will continue to stand as giants in their totally different fields runs curiously parallel. Both were supplied by fate, to test their wits and strength in early childhood, with mighty and gigantic "toys."

In Mark Twain's case, it was the rolling Mississippi with its rafts, floods, and steamboats, runaway slaves, robbers' caves . . . you know. . . .

In Robert Wood's case, it was the roaring, giant Sturtevant Blower Works with its power plant, hydraulic rams, chemical vats, blast furnaces, engines, tools, and machinery, which you shall presently see.

I know Robert Wood pretty well by now, having worked and played with him for a long time, and I hope I can suc-

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ceed in showing him to you as he really is. There is something fantastic, Gargantuan, Promethean about the man, but to this very day, with Wood in his early, active, robust seventies, there lurks grinning and leaps out continually from behind that fiery curtain of fantasy and scientific genius, the American small boy's *dream of himself*—the American small boy who has become a great man yet has never grown up.

I keep repeating American because this Wood of mine is as American as a hickory tree. America is in the roots of him. The brightest little French or Greek boy wouldn't have the remotest idea what he's all about—any more than they can really understand Huck Finn. And he's often shocked his little British cousins, though they've showered him with all their highest honors. No little land, indeed no other land on earth, could have produced this man.

WILLIAM SEABROOK

Rhinebeck, 1941

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Doctor Wood

MODERN WIZARD OF THE LABORATORY

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CHAPTER ONE

Small Boy with a Gigantic Toy—Wood Starts Early at Playing with Fire—and Ice

THERE is a family legend that Robert Williams Wood wrote a letter to his grandmother on the day he was born. The letter in question is extant. I have read, handled, and examined it. It is dated Concord, May 2, 1868. Its obsolete paper, faded, rusty ink, et cetera, all prove the authenticity—at least—of its date. It reads:

MY VERY DEAR, VERY GOOD
GRANDMAMA WOOD,

Mother is not able to write today—and she therefore desires me to announce to you my arrival this morning—which was about two weeks *sooner* than had been expected by my friends. So that I had the satisfaction of taking them all by *surprise*. I had not a very long journey, although what seemed to me a rather rough one, of thirty-six hours.

I did not, however, on my arrival find myself at all fatigued, but on the contrary in most excellent health and spirits.

"What strong lungs he has got," say my friends, "and what bright blue eyes."

In due course of time I shall call to pay my respects to you in person, should we both live. Mother directs me to send her love to you, and to subscribe myself

Your affectionate Grandson,
ROB'T WILLIAMS WOOD, JR.

To Mrs. Elizabeth Wood,
Augusta, Maine

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This is the one and only legend concerning this great, fantastic physicist, among a thousand now world-famous in scientific circles, which he categorically denies. He confesses to Promethean pranks, conflagrations, and explosions in his early childhood, to courting his fiancée vocally across the continent with wax phonograph cylinders mailed in baking-powder cans; confesses to the cat in the spectroscope, the trained seals he persuaded the British government to use in tracking submarines; confesses even to "purloining" the purple-gold sequins from Tutankhamen's tomb, via the Cairo Museum—but denies that he wrote the above letter.

He said to me last summer, "I have never subjected it to my ultraviolet light tests now in general use on dubious manuscripts, but I am convinced that the signature is not mine. As a matter of fact, from certain internal evidence, I believe that the entire letter constitutes a forgery committed by my father." [1]

[1] A separate book might be written about the father, who if he were still alive would not be taking this aspersion lying down. He was born April 22, 1803, and had been twice around the Horn before 1840. This was in the days when "Died in Pernambuco" occurred on the tombstones of bodies which had been brought home to Nantucket, New Bedford, and Boston. The South Pacific was a suburb of New England towns whose railed cupolas looked out over the sea. This grand old scholar and adventurer, worthy sire of a great, fantastic son, was born in Stowe, Maine, son of Joseph Wood and Betsy Williams; graduated from Waterville College (now Colby University) 1829, and from Bowdoin College Medical School 1832. Sailed from Boston for Hawaiian Islands October, 1838, arrived April, 1839 (around the Horn). By appointment of the American Consul was for ten years in charge of the American Hospital for Seamen in Honolulu. For twenty years subsequently was engaged in the growing and manufacture of sugar, a pioneer and the first financially successful one, in the introduction of this industry into the Hawaiian Islands. He retired from the Islands in 1866 and retired from all business in 1879. Married (June 4, 1833) Delia Morse, daughter of Samuel A. Morse, for many years Collector of Customs at Machias and subsequently of Eastport, Maine. Second marriage was to Lucy Jane Davis (October 31, 1864), daughter of Charles B. Davis of Concord, Massachusetts. They lived in Honolulu for two years, then a year in Europe. Robert, Junior, was born May 2, 1868, in the Davis home in Concord. They lived in Concord for four years in the Davis home, as Grandmother Davis was a bedridden invalid. After her death, they moved to Jamaica Plain, a suburb of Boston. In 1868, year of Wood, Junior's, birth, Dr. Wood, Senior, again sailed for Honolulu. His ostensible purpose was to collect biological material for Louis Agassiz, of which he brought back plenty before the year was out—but it amuses

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If the letter was not authentic, it was at any rate miraculously prophetic. All his life, he has been arriving "sooner than had been expected." Concerning some of his greatest scientific achievements, later rediscovered and cashed in on by others, the *Scientific American* had an article not so long ago entitled "Too Soon is as Bad as Too Late." His pyrotechnic originality is still continually "taking people by surprise" and he is so hyperkinetic that he never seems to know fatigue. He was seventy in May, 1938, and would normally have been retired as head of the Physics Department at Johns Hopkins University. Instead of his being retired as "Emeritus" he was appointed Research Professor of Physics at the same university, and is going stronger than ever. Last summer, 1940, when I was with the Woods at East Hampton, he had just been awarded the Draper Medal by the National Academy of Science, for work which he has done, since his retirement, in so

me to imagine that he may have been fleeing from the "lusty lungs" of his Gargantuan son. Those lungs still contain a lot of noble wind about the father. I wanted to hold the father in a footnote, and am still trying to, but here's what Wood added—and there's still more to come. While Wood, Senior, was in charge of the American Hospital for Seamen at Honolulu, a Russian warship anchored and the admiral came ashore. The admiral was entertained frequently by Dr. Wood. On the night of their last dinner, they exchanged keepsakes—a little gift from Dr. Wood to the admiral, and a little gift from the admiral to Dr. Wood. Next morning Wood received with the admiral's compliments a valuable book which he'd chanced to admire on the flagship. These Woods are well bred, but tough. Wood tore from the wall and boxed up an oil painting which was worth five times as much as the book—and which the admiral had chanced to admire. Wood had his servant deliver it to a petty officer with instructions that it was not to be given the admiral until the ship had cleared port. The ship duly cleared —but put about and dropped anchor off Diamond Head. A cutter came ashore and a box was handed to the harbor master, addressed to Dr. Wood. It contained a cup of solid platinum, worth many times its weight in gold. The warship had meanwhile weighed anchor and disappeared. The father of Wood, perhaps for the only time in his life, was licked. Here comes the last of his father, and if it doesn't give you goose flesh, it's because I can't write. Wood, Senior, lay sick abed in 1892, at the age of ninety. Old age was his only illness. But old age had laid its hand upon him. After a number of days, he arose on his pillow and said in a loud, strong voice, *"I want to give up the ghost!"* He lay back and died of old age with a terrible if unconventional dignity which gives to think of Captain Ahab and the Whale.

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improving diffraction gratings that they are now replacing prisms in the great star spectrographs of the larger observatories. Current gossip about him in Europe has been that most younger associates who worked with him over there broke down from exhaustion and were obliged to take a rest cure every couple of months while he worked on.

The old adage that the child is father to the man has never had a more astounding confirmation than in the case of Wood. By the age of eight, he had already become a sort of potential triple cross with the characteristics of an infantile Prometheus, a poltergeist, and Crile's Irish Elk. Put in simpler words, the embryonic scientist was a holy terror. He is to this day. In the midst of my work with him at their East Hampton place last summer, the disturbingly beautiful but even more disturbingly not dumb Marya Mannes, daughter of David Mannes (now Mrs. Richard Blow), who had known the Woods intimately since she was sixteen, said to me, patting one of Wood's bony, powerful, extraordinary hands affectionately:

"You ought to enjoy this work. It's right up your alley, isn't it?"

I said, "What do you mean?"

She said, "Haven't you generally written about savages, cannibal kings, and wild men?"

I said, "I wouldn't be the one to write a biography about a tame man. I wouldn't know how."

Wood is full of a sort of detached affection and kindliness, but he has no deep respect for and no humility toward anything on earth or in the starry heavens except the laws of nature. He has no fear of man or God, or anything—except perhaps occasionally Mrs. Wood.

It is no mere "legend" but a fact in family history that at the age of eight, Wood gave a lecture on the anatomy of jellyfish, illustrated with magic-lantern slides which he himself had redrawn from the pictures in the scientific treatise by Agassiz. They had given him a magic lantern to play with,

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with a few colored slides. He had tired of the clowns and angels, and had made his own slides as substitutes. The lecture was given in the dining-room, with some of the neighbors' children and their mothers present.

Said Gertrude Wood, his tolerant but not always meekly long-suffering wife, as we were discussing this childhood episode, "Thank heaven, that was one lecture I didn't have to attend."

A contributing influence to his Gargantuan precosity was the fact that while he was still at the age when children like to play with toys (and was being bored to death in "Mrs. Walker's Select Day School" for nice little boys and girls of good family, where he stood continually near the bottom of the class), he had been given, to play with, one of the most powerful and dangerous toys that has ever fallen into the hands of any child in the history of the world. It contributed to his subsequent scientific achievements—for it was the immense blower plant and factory of B. F. Sturtevant, at Jamaica Plain, outside of Boston.

When young Robert was about four, the family had moved to Jamaica Plain, then an attractive Boston suburb. He had been born in a quaint old house at Concord, and had been dandled as a baby on Emerson's knee. The Woods had had culture from earliest Colonial days, and Dr. Wood, Senior, had brought back a considerable fortune from the Hawaiian Islands, where he had pioneered in the cultivation of sugar cane.

Their next door neighbor in Jamaica Plain was Benjamin Franklin Sturtevant, founder of the still existing Sturtevant Blower Works for the manufacture of air blowers for mine shafts and other huge devices for ventilation. The Sturtevants had an only son, Charlie, three or four years older than Rob Wood, and the two little boys immediately became friends. It was this friendship, which grew as both became a little older, that led to Rob's acquisition of the blower plant as a

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childhood toy—and the way it happened is a beautiful story of childhood friendship, ending on a note of sadness.

Dr. Wood says:

I looked up to and admired Charlie. He was nearly four years older, as I remember, and I was terribly anxious to be noticed by him. The Sturtevants had a large greenhouse in their back yard, and Charlie had a beautiful aquarium, almost like a swimming-pool, with various fish in it. I must have been seven or eight, and had begun to collect butterflies with a net I'd made of mosquito netting. One day as I passed along a small canal ditch by the roadside, I saw little fish swimming there, waded in, scooped some up, threw away my butterflies, and put the fish in my glass jar and took them home to Charlie for his aquarium. I said, "I don't suppose you'll want them, they're only common minnows." Charlie examined them and said, "Why, those aren't minnows! They're fine *game* fish. They're baby pickerel." I was thrilled and happy, and from that time on Charlie began to show some interest in me. Then Charlie did not appear for a long time, and I was told one morning that he had died. I was stunned for a few days and could not realize that I would never see him again. Now that Charlie was gone, and the factory was completed, Mr. Sturtevant, I think, must have transferred to me some of the affection he had had for his own son, for he frequently called me to the fence between our gardens and talked to me. When I was about ten years old, he took me all through the huge factory one day—the great Corliss engines, the iron foundry with its blast furnaces, the lathe rooms with their enormous belts and flywheels, machine shops, pattern shops, carpenter shops—everything. He introduced me to the superintendents of the various shops and told them to let me come there whenever I wanted to and to let me do anything I wanted, so long as I didn't hurt myself.

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So that, at an age when most mechanically inclined kids are playing with toy sets of tools and tiny scroll saws in the family woodshed, Rob began not only with the traditional "buzz saw," but with mighty power-driven machines, hydraulic rams and engines. That he didn't kill himself—in fact never even had a serious accident—is a tribute to his own skill—and probably also to the friendly watchfulness of foremen and workmen. He was soon literally doing anything he pleased. The workmen in the iron foundry even taught him how to make sand molds, into which they poured the molten iron for his castings. Rob sometimes made mistakes—seldom dangerous ones. He kept a little diary of his exploits, illustrated with his own drawings but devoid of reading matter: this is still extant. The first drawing is the episode of the dumbbells. It occurred before he had begun to understand the plant's gigantic possibilities. He had put a block of softwood on a big power lathe and started trying to make a pair of dumbbells. Chunks instead of thin shavings were flying, and he had wrenched his hand when a foreman passed, stared, and said, "What are you doing?"

Rob said, "Making a pair of dumbbells."

The foreman said, "Well, I see one fine dumbbell already. That's not a chisel you're using. It's a screw driver!"

On another occasion, he took a scolding from a superintendent of the plant, E. N. Foss, who had married into the Sturtevant family and was trying to prove his worth by small economies. (He later became governor of Massachusetts.) Rob had decided to make an electrical machine which required a large, circular glass plate. Not knowing how to obtain this, he sawed out a circular disk of a dark heavy wood which he intended to varnish. Several days later his mother received a letter from the new superintendent complaining that Rob had destroyed two square feet of "bay mahogany" worth forty-five cents a square foot. Mr. Sturtevant's new son-in-law had seen the board from which the circular disk had been cut, made inquiries of

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the workman, and been told that it was done by the boy Mr. Sturtevant had brought down. Rob was severely scolded by his mother and confined for two hours in the "blue room" (guest room, but used as a jail on occasion).

All this, of course, was trivial child's play, merely a beginning. But even at the start, access to the tool shop, plus his own ingenious imagination, made him a ringleader of the "gang" outside school. Rob had found a book about Norway, with descriptions and pictures of skis. He had never heard of steaming wood to bend it, but went to the Sturtevant works, cut out a pair of skis with a mechanical saw, and curved the ends with galvanized iron and countersunk screws. Next day, he took them to the snow-clad hill where his friends were coasting on sleds, put them on, stood in a superior manner, slid about fifteen feet, and turned over in a snowdrift.

The crossbow came about because Rob's parents wouldn't let him have a gun while two of the boys in his gang had rifles. Rob and the less fortunate ones went hunting with slingshots. He had read somewhere about the steel crossbow, and proceeded to make one, with the help of the shop foreman. Shooting an arrow tipped with a heavy bolt of steel, which he also made, it penetrated oaken targets deeper than any rifle bullet. What impressed the boys most was that it kicked like a shotgun.

Another discovery that made him a sort of king among the kids was that he had learned to apply the principle of the siphon, with the help of an old book of his father's and a bent stick of macaroni. There'd been a thaw in January, and a flat space at the bottom of the boys' coasting hill had turned into a little pond of water. This was bad, because as you coasted down where there was still ice you gathered speed. Then your sled hit the pool and you were drenched with mud and water. Girls on their high runner sleds came down less rapidly and went through fairly well, but no boy, of course, would use a girl's sled. You simply went on doing belly-whoppers on your

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own sled, to end soaking wet and covered with mud. Rob appeared with a garden hose and announced that he proposed to dispose of the water. His gang, including older boys who went to the same school, was derisive. There was a rise of more than a foot around the pond, and everybody knew that water wouldn't run uphill. Rob laid out the hose on the ground, had one of the boys stop up one end with his thumb and poured water into the other end until it was full. Already an embryonic showman, Rob took this end and, instead of laying it on the sidewalk, lifted it up over the high fence which separated the road from the lowland bordering the street. Of course the water came rushing through. It was perhaps Wood's first public scientific triumph.

Another thing that gave him an ascendancy in the gang was that he had learned all sorts of chemical tricks from the books on his father's shelves and by his own crude, often daring, experiments. He had a love for fire, which has stayed with him all his life, and took particular delight in explosions and loud bangs. Here again the child was father to the man, for he is a leading authority on high explosives, found the key to the reconstruction of the Wall Street bomb, and has solved a number of bomb mysteries and murders for the police.

He had learned, when he was about fifteen years old, that chlorate of potash and sulphur, both cheap and easy to buy, when mixed together and wrapped in paper and hit with a hammer made a noise louder than any cannon cracker. Not content, he made a larger package, laid it on an old anvil, and hit it with an ax. The explosion nearly broke his arm. This didn't discourage him. He was all for bigger and better noises. When Fourth of July approached he bought twenty pounds of the stuff and with the help of his cousin Bradley Davis and the boy next door set some posts in the earth and built a pile driver ten feet high with a heavy iron weight which when released from a catch at the top by a long cord

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fell on the old anvil. The first time they tried it, as he joyfully remembers, complaints came in that "the horses in a stable some doors away nearly stampeded, and the windows in neighboring houses rattled." What he remembers best is that the concussions tore the leaves off all his mother's raspberry bushes.

Bradley Davis later escaped Rob's Mephistophelian influence and is now professor of botany at the University of Michigan in Ann Arbor!

The three young devils had eight or ten pounds of the explosive mixture left over at the end of the day. They hid it in the cellar of a new building under construction near the railroad station and went blithely off to Boston to see the fireworks on the Common. Rob had learned that if you don't hit the stuff with a hammer—or a pile driver—but merely put it in a pile and set it afire, it doesn't explode but burns with a fierce blue flame. They were going to top off the evening by lighting up the town on their return. Rob didn't know everything about the stuff's properties yet, and they had the unfortunate idea of utilizing some leftover firecrackers so that the flare would be accompanied by pleasing though small detonations. On their return shortly after midnight, they set the mixture, surrounded by cannon crackers, down in the middle of the street in front of the Congregational Church, lighted the chemicals—and ran.

Says Wood:

> Before we'd run half a block one of the cannon crackers went off, and the whole mess exploded with a terrific detonation, followed by loud tinklings of glass from windows of the neighboring houses. The street lamps were extinguished by the concussion, and the whole square suddenly became dark. We ran all the way home and I entered the house as quietly as possible, but mother was awake and called out to me, "Rob, what was that terrible explosion?" I pretended not to hear.

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His relations with his father and mother were "friendly," he says, and he has no recollections of serious clashes. This is remarkable when one considers that Rob's father was eighty when he was fourteen, and that while all boys of that age are fiends, Rob's superendowments made him a superfiend.

On Decoration Day, in 1883, there was to be a parade around the Jamaica Plain monument to the veterans of the Civil War. It was the usual granite monument, surmounted by a soldier leaning on his gun. Rob decided that the monument needed decorating, so, with the help of the boy next door, he procured a large, broad-brimmed farmer's straw hat, with an elastic to go under the chin. They trimmed it with rosettes of red, white, and blue and a bunch of long streamers of the same colors. The problem was to get the hat on the soldier's head and slip the elastic under his chin to prevent the wind from blowing it off.

They surveyed the monument the afternoon before the parade, and Rob figured out that he could climb half way up but that the last ten or twelve feet were unscalable. He found a wooden pole about fifteen feet long and topped it with two horizontal jaws held together by elastic rubber bands. The lower jaw could be opened by pulling a string.

At 2:00 A.M. on Decoration Day, Rob crept out of his house and woke the boy next door by standing under his window and yanking a long string that had been attached to the sleeper's big toe. Then Rob climbed the monument, with the hat firmly clamped by the jaws of his pole. He soon got the hat on the soldier's head, and by careful manipulation adjusted the elastic under his chin. Stealthily the two boys crept home. Next day, they were sure they would be arrested if they dared step out of doors. So they had to miss the fun of watching irate citizens call out the fire department, with its hook and ladder, to remove the "abominable desecration."

Another typical boy's prank, with its special Wood touch, was monkeying with the doorbells of a new apartment house

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that had been built not far from the Roxbury Latin School where Rob was being bored to death. There was something fascinating about the long row of speaking tubes with push buttons beneath in the vestibule. The idea came suddenly to Rob one day that it would be simple to "short-circuit" them.

He found just what he was looking for at home, in the closet where wrapping paper, string, etc., were thriftily kept. It was a long pasteboard mailing tube about three inches in diameter. This he held against the battery of speaking tubes in the apartment-house vestibule, marking circles on it to coincide with the mouthpieces of the tubes. Later he cut these out with a sharp penknife and closed the open ends of the pasteboard tube.

Then, with the aid of his friend who lived in the house, he fitted this gadget over the speaking tubes, by which operation a multiple "party line" was introduced, making general conversation among the tenants possible.

The little devils then pressed all the push buttons, beginning with the top floor to facilitate a safe getaway. The ensuing confusion, resembling a new Tower of Babel, can be imagined.

Says Wood today, looking back to that part of his childhood spent in the Sturtevant plant:

The first really interesting thing I found in the factory was something that gave me a start in the study of electricity. I noticed that on going down a long dark passageway which conveyed a huge belt carrying the power from a flywheel to the blower operating the blast furnace, my hair always stood on end. I thought at first it might be because I was afraid. But I knew I wasn't afraid and sought some other explanation. I wondered if there was a wind coming from somewhere. I held my hand up toward the whirring belt to see if wind was coming from it. Immediately purple streamers of fire began flying from the ends of my fingers. I was fascinated and excited. I put my hand closer to the belt, and a long spark

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leaped out to my hand. Like all children, I knew about electric sparks from the cat's back, from shuffling along a heavy carpet and touching a doorknob—and I had found out how to pick up tiny bits of paper with sealing wax subjected to friction. I had also been reading Arnold's *Elements of Physics*. In consequence, I realized at once that in that belt from the great flywheel I had a powerful static electric machine at my disposal. I know now that the belt I began to use might almost be considered the progenitor of the Van de Graaff generator. I made Leyden jars and various others pieces of apparatus which are only practical with a source of electricity of considerable volume.

I never had a serious accident, but once I had a narrow escape—nearly lost my right hand and perhaps part of my arm. No matter how big and powerful machinery becomes, one of the most dangerous things in any shop remains the power-driven buzz saw. I had a heavy board on the buzz saw once, when it suddenly jumped out of my hand, but in the jumping pulled me forward so that my wrist almost went down on the saw. The workmen told me that I had got hold of a piece of "springy" wood. After it passes the saw, it clamps together on the saw, then jumps and pulls you forward.

Wood had by that time begun playing with and experimenting with all the big machinery including the hydraulic presses. He apparently refrained from inflicting on his mother any confidences concerning his experiments and narrow escapes. He played there only after school and Saturdays, since she was meanwhile sending him to Mrs. Walker's select "fitting school," and later to that of another unfortunate lady, Miss Weston, a spinster. Rob's outstanding memory of Mrs. Walker's was when two of the older boys locked her in the water closet, which opened off the main schoolroom. When she'd been released from durance indeed vile, she pinned it down

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on two brothers, past masters of mischief, and said before the whole school:

"Malcolm and Isaac, pick up your books and go straight home and never return to this school!"

The boys strapped up their books, but one of them turned on his way out and called back:

"Mrs. Walker, here goes three hundred and fifty dollars straight out through this door." They were of course back again in two or three days.

Mrs. Walker's reports of young Robert, in the meantime, were completely discouraging, though not so scandalous. She said he was inattentive, almost dull, and that his mind seemed almost always to be "wandering somewhere else."

Where else it "wandered," when it wasn't absorbed at the Sturtevant plant or in exploding bombshells, Dr. Wood tells in his own words. The account goes back now somewhat in time sequence, but helps fill out the picture.

We had practically no science at school, though they had something they called botany at Mrs. Walker's when I was about eight or nine years old. I hated it and did very badly in it—as in everything else. It consisted of something they called analyzing flowers. A flower was laid on your desk and you were supposed to find its name by looking it up in the botany book, in which the various parts of every flower, calyx, corolla, stamen, pistil, et cetera, had been classified in tables. You would find the top of a vertical column and then follow it down to the proper horizontal column, where you would find a reference to another page of tables, in which the process was repeated. You would eventually come out with the name of the flower in the end, if you knew how and had made no mistakes. It interested me about as much as crossword puzzles do at the present time. I did become interested at the age of nine or ten, however, playing what I suppose now would be called plant physiology, planting an acorn or a bean, and after it had

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got well started on its way to the surface, turning it upside down to see what would happen, putting pollen from a pear tree on the pistil of an apple blossom, and other strange experiments in cross fertilization. I learned to cut twigs from the trees in winter, and put them in jars of water in the sunshine and watch the buds swell and the leaves come out; watered plants with red ink to see if the white blossoms would turn pink; planted seeds in a flowerpot, covered with a plate of glass and placed in the sun, and was charmed to note that when I lifted the glass and sniffed, it smelled exactly like Sturtevant's greenhouse next door. My father gave me a very fine microscope and Carpenter's large volume on microscopy. This started me on excursions in which specimens were brought home from brooks and pools, in glass jars, to be examined under the microscope. Microscopy was a "science" in those days, the science of anything small. Even today, there is a Royal Microscopical Society in England, of which I am an honorary member. I mounted slides and had a large exchange list with other enthusiasts, having correspondents in practically every state. At one time I was mailing living aquatic specimens in small bottles of water in exchange for mounted preparations.

My father believed in teaching me the value of money by making me "earn" my spending cash from earliest childhood.[2]

[2] In his notes there kept occurring a story about how when he was 13 years old, his father had taken him in to Boston and bought him for $100 or more, a high-wheeled, man-sized Columbia bicycle. He kept putting it in, and I kept leaving it out. His final plea for its inclusion didn't impress me. Here's what he wrote.

"The only excuse for the Columbia bicycle was to illustrate a trait which I inherited from my father, whose reaction in matters of expenditures resulted from a mixture of New England thrift and Hawaiian lavishness. I was conditioned in my youth against extravagance in spending *pennies,* but have formed no fixation against spending *dollars,* whether I possess them at the moment or not. Gertrude says I always take a day coach for short trips alone, but engage a drawing-room on *The Chief* when we go to California."

He hasn't been generally too insistent about what goes in or what comes out, but he was plaintive about the bicycle. It was as if I had taken it away from him. I began finally to understand that this bicycle was very important to him—but couldn't understand why, since his economic explanations had

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We had about an acre of ground behind our house at Jamaica Plain which was utilized as a vegetable garden. Finding out that the local butcher sold small sprigs of mint to his customers, for fifteen cents, I had my father arrange with him to get his supply from me. We had a small mint bed in the garden for our own use, but by transplanting and spreading it out I succeeded in producing a most luxuriant bed about ten feet square. Every morning before breakkast I used to run down the hill to the butcher shop by the railroad station with a magnificent bunch of fragrant cuttings, for which he paid me five cents. From this he could easily make fifteen or twenty bunches of the size which he sold for three times the money. The tasks which I most disliked were picking potato bugs from the vines and digging up dandelions in the lawn which surrounded the house. But from these sources I derived most of my income. My earliest expenditures were chiefly for rubber bands to make slingshots, and mineral specimens purchased at the natural history store in Boston, for my collection of minerals. Later on my purchases included chemicals and materials for making fireworks. My father gave me a geological hammer, armed with which I scoured the quarries in the vicinity of Boston for minerals and fossils. These, together with the specimens that I bought from time to time, eventually made quite a sizable collection.

The expedition which caused me the greatest excitement was a trip which I made to Braintree on my bicycle to the world-famous quarry where the giant trilobites, *Paradoxides harlani,* are found. It's curious how you remember the scientific names

left me cold, when it belatedly dawned on me that the reason is because he's still riding it—and will to the day of his death. If after his death he approaches the Pearly Gates, it will be on that bicycle. And he will expect and be given the special welcome he deserves.

"Here comes somebody on a high horse—or high wheel—instead of a kindly but dumb and perhaps foot-weary nobody."

This begins to illuminate the combination of always well-bred arrogance, not always so well-bred egocentric impudence and impishness, combined strangely with sweetness and light, which makes this man unique.

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of ace specimens in your collection. I had read somewhere a fantastic story about these trilobites, that they were not found anywhere else in the world, and that some scientific romancer had propounded the theory that they might have been brought to the earth on a meteorite. I secured such a heavy bagful of them that it was only with great difficulty that I could mount to the seat of my high-wheeled bicycle.

One day I ran into a young man who had an amethyst crystal which he said he had found in a quarry. It contained two cavities filled with liquid, clear as water, in each of which a small air bubble moved to and fro when you turned the crystal sideways. I had heard of *quartz* crystals containing moving bubbles but had never seen one, and this was an *amethyst* with bubbles! Was there another in the whole world, I wondered. He wanted five dollars for it, and I wanted it more than I had ever wanted anything in my life. I teased and teased my father to let me get it, not in my mother's hearing, however, but he thought the price was a little high, and he was a little doubtful, I think, about the air bubbles moving around in a liquid in the crystal. The young man lived in Boston, and my father said, "You tell him to bring the crystal out here and let me see it." So one evening the young man appeared with his crystal. He would not, however, come down in his price, and my father after demurring for some time finally handed out a five-dollar bill and I pocketed the crystal. "Don't tell your mother how much we paid for it," he said. I still have the amethyst and the moving bubbles are still there.

During my early boyhood we always spent a part of each summer at Kennebunkport. That was in the days when you drove over from Kennebunk in an old stagecoach, and there were always one or more schooners in process of construction along the river. One summer I invented the game of writing a note and putting it in a glass bottle tied to a long spar or boom, to be towed out to sea by a paper kite when there was an offshore wind. The note requested the finder to return the paper

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with a statement as to where the bottle had been picked up. (One was actually returned by a native of Nantucket!) When the wind was not directly offshore, I found that by putting the nail to which the kite string was fastened two or three feet aft the forward end of the spar, it would sail straight out to sea, with the kite flying 45° or more on the quarter. It was a thrilling sight in a strong wind to see the spar or log rushing through the water like a torpedo with no visible means of propulsion and with a "bone in its teeth." I often wondered what the crews of passing ships thought of it when encountering it, the kite string being invisible except at close quarters.

Then came astronomy, one of my father's friends having lent me a very fine five-inch glass telescope, and I was out every clear night. I took no interest in the constellations or their names. This was like analyzing flowers. But I was fascinated by watching the moons of Jupiter as they circled around the planet, casting their shadows occasionally on the disk, the craters and mountains on the moon, Saturn's rings, and the nebulae.

About his early formal education—to get back to chronology—his mother, with Harvard as the later goal, had hoped that Robert could enter Roxbury Latin School at the age of twelve, and he evidently wasn't going to be able to if he remained at Mrs. Walker's. So she had taken him out and sent him to Miss Weston's School, in Roxbury. To his mother's joy, and perhaps surprise, he had managed to "get by" at Miss Weston's, and entered Roxbury Latin. His entrance was deceptively triumphant. He had appeared with other applicants. The principal of the historic school, the redoubtable William C. Collar, commonly called "Dickie," stood before the applicants with a sheaf of papers in his hands. Rob feared that he had failed again or that if he squeezed through he would be at the bottom of the list of those admitted. Then Dr. Collar began reading, and read:

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"The first boy admitted is Robert Williams Wood."

Dr. Collar had been intending to read the list of admissions alphabetically, rather than for merit, but in fumbling the papers had got the list reversed.

Rob's auspicious but deceptive place at Roxbury Latin was soon rectified. He fell at once to the bottom of the class and remained there through the whole first year. During the first few weeks of the following year his place in the class was near the top, but he soon forged his way back to the bottom and was dropped at the end of the second year.

This was discouraging. But Dr. Wood, Senior, and Rob's mother were bent on Rob's following family tradition and going to Harvard if possible. So they sent him next to the William Nichols Classical School, in Boston, which specialized in Latin and Greek. Rob had no interest in Latin and Greek, while Mr. Nichols had a deep distaste for science. These mutual distastes were emphasized and took on a slightly personal tinge through the episode of the circular staircase. The staircase at the Nichols School, on Temple Place, was a tight spiral with its bannisters riveted to the walls of a plastered well, like the interior of a lighthouse. All boys like to slide down bannisters, but they couldn't slide down these because they couldn't straddle them and they were so close to the wall that you couldn't sit on them. Young Wood knew something about centrifugal force, and began experimenting with the balustrade. Taking a running start from the top of the steps to gather speed, he slid side saddle onto the rail and found himself coasting with increasing velocity around and around clear down to the bottom, where he landed with a bang. The other boys marveled and tried in vain to imitate the performance, but Wood would not allow them to witness the start. It was too wonderful. Centrifugal force pressed your back against the wall, giving you a firm seat, and away you went. Wood says that he has kept his eye open for a similar slide ever since, as he would like to repeat the performance.

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Finally he initiated the others, with the result that in a day or two a torrent of laughing and screaming small boys poured off the last turn of the spiral landing on top of Mr. Nichols, who was just entering the street door.

Rob was given a letter to his father. Next morning he was called up before the whole school and asked what his father had said to the letter. Rob gleefully announced that he said he was glad it was nothing worse.

His progress in his own growing scientific-imagination-fostered fantasies began to reach new heights.

As one result, he concocted two elaborate hoaxes. One had no wide repercussions, but the other made a national sensation. During a summer visit to his uncle, Charles W. Davis, in Chicago, he and young Bradley Davis went fossil hunting together. There was a limestone quarry which they visited frequently, rich in Silurian fossil shells and crinoids. Once, while alone, Rob chanced on two large broken slabs of concrete, smooth on the surface, covered with rubble on the back. With a hammer and chisel, he carved on the surface of one the head of a pterodactyl, and absurdly on the other, the outline of a gigantic bug, a sort of imaginary prehistoric devil's darning needle. Then Rob and some fellow-conspirators "planted" these in the quarry and on the next fossil-hunting expedition he ingeniously steered his young cousin Bradley to the buried treasure.

"His excitement," said Wood, "at this rich double find was as great as that of the man who discovered gold on Sutter's ranch in California."

Rob photographed the "fossils" with a homemade camera and still has the faded blueprint.

The second hoax stirred up national excitement and for a short time almost rivaled the comedy of the bogus Cardiff giant. It was pure hoax, pure fantasy. One of his father's friends had lent him a big telescope, and he had begun looking for life on Mars and other planets. He didn't find any, but on July 23,

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1887, the following amazing article, which he had concocted out of his own untrammeled imagination, appeared in the Chicago *Tribune*.

A STELLAR VISITANT

AN INCANDESCENT VISITOR FROM SPACE—MARKED WITH GRAVEN CHARACTERS

Clayton, Ga., July 21.—(Special)—A phenomenon unparalleled in the annals of astronomical science occurred here one day last week, which, from the light it throws upon the hitherto open question of the habitability of the other planets, will prove of great value to science. At 7:45 o'clock P.M. there fell near this town a spherical metal ball or aerolite on the surface of which appear graven characters which give conclusive evidence of its having been molded by intelligent hands. Dr. Seyers, in whose possession the wonder now is, said this evening: "I was returning from a patient's house, situated some seven miles from the town, where I had spent the latter part of the afternoon. It was about 7:45 o'clock, though still light enough to read by. I was ascending a long hill, over which it is necessary to drive before reaching home, when my horse suddenly pricked up his ears, and, on glancing ahead, my eyes were dazzled by a brilliant white flash, resembling a lightning stroke, and immediately following came a sharp hiss as of escaping steam. I knew that an aerolite had fallen, for had the flash been electrical there would have been a clap of thunder. Driving on up the hill I noticed that steam was issuing from the ground some few rods back from the road, and on hastening to the spot found a hole about four inches in diameter, from which arose considerable heated vapor. I drove home as rapidly as possible, and taking a pick and shovel returned to the spot. After half an hour's hard digging I came upon the object of my search at a depth of about five feet. It was still too hot to handle, but I succeeded in getting it to my carriage by lifting it on the shovel. I noticed that it was remarkably heavy, but not until I reached my barn, and removed the adhering soil, did I realize what a prize I had. Instead of a rough mass of meteoric iron, there appeared a smooth, perfect sphere of steel-blue metal, with polished surface and engraved with pictures and writings. I could scarcely believe my eyes, but there was no mistaking facts. There upon the surface of the strange ball was a deeply-graven circle within which was a four-pointed star, a representation of a bird-

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reptile resembling in a measure our extinct archaeopteryx, and a great number of smaller figures, resembling those used in modern shorthand. The metal of which the ball was composed was unlike anything I had ever seen, being about as hard as copper and entirely infusible in my Bunsen blow-pipe. I filed off some small bits and sent them to a chemist, who made the following report:

"Sir: I have made a spectroscopic analysis of the filings you sent. The metal is fusible only in the electric arc. It is a new element. Examined by the spectroscope, its vapor gives three fine yellow lines to the left of the D. line of Sodium, a broad green one to the right of the line of Barium, and an innumerable number of fine purple ones.

H. Randolph Stevens,
Analytical Chemist."

Whence came this strange messenger? By what infernal power was it hurled into space? Possibly by some monster gun on Mars or Venus. Possibly launched toward us by some lunarian gunner. Many there are who will say that the whole thing is a hoax and a fable, and that the ball was manufactured on this earth, but the fact that it is made of a metal not found upon this sphere proves beyond a doubt that it is an alien. Hurled with frightful velocity, it traversed the vast distance of space separating us from our nearest neighbor, and, plunging through our atmosphere, became heated to incandescence, and thus losing some of its fearful speed buried itself in the soil of our planet without suffering any injury. How shall we determine whence it came? Is it possible to reply, and can a sort of communication be established between planets? A gun 130 feet long and strong enough to hold a charge of thirty pounds of dynamite would hurl a platinum bullet of two inches in diameter with a velocity sufficient to cause it to pass beyond terrestrial attraction. The dream of Jules Verne has in a measure become realized, and we are, without doubt, standing a bombardment from space.

The ball is now in the possession of Dr. Seyers, but will be sent to the Smithsonian Institution in a short time, when an official report will be made.

Despite all this brilliant extracurricular activity, the boy continued a dullard in the classrooms of William Nichols's Classical School in Boston! In this day of advanced specialization in education, the stupidity of his preceptors seems more shocking

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than it actually was then. A boy like Wood would be encouraged *today* to go into his natural field by all intelligent prep-school professors who knew him. But the "classic" tradition was still completely hidebound in New England, with the result that as he approached eighteen, and the Harvard entrance examinations, he faced almost certain failure. Here, for the first time, he began to take the direction of his studies into his own hands in spite of the violent opposition of Headmaster Nichols. The boy's only real interest and bent were towards science. It might be said in extenuation of Mr. Nichols's prejudices that they were almost universal in the Boston of that day. M. I. T. was a long generation in the future for the likes of Robert Wood. A gentleman's son was supposed to stick to the classics. Against the opposition and definite orders of the headmaster, Wood bought secondhand books on physics and botany, not because the latter interested him much, but because it could help him pass the Harvard examinations. When the smoke blew away after the entrance examinations in the spring of 1887, he found himself admitted to the freshman class, though he had failed ignominiously in Latin and Greek —purely and simply because he had crammed himself brilliantly with science. Up to then he had treated chemistry, physics, astronomy, and biology as amusements and play, rather than work—but he had built a magnificent practical foundation.

To what extent the "gigantic toy" (the Sturtevant Blower Plant) entered into that foundation is shown by the fact that after he entered Harvard, he streaked back to the Sturtevant plant one day, and with the aid of its mighty machinery, succeeded in exploding the "water-lubricated" glacier theory which the great geologist, Nathaniel Southgate Shaler, was teaching at the time. Shaler was brilliant, popular, and internationally famous in his field, but young Wood, who took nothing on faith, had many run-ins with him. One of their arguments culminated in a conviction on Wood's part that

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Shaler was entirely wrong in his pet theory that the mysterious absence of glacial erosion in wide areas of North America was due to the fact that certain glaciers had been of such terrific weight that the pressure had melted the ice at their bottom and given them a sort of liquid cushion to slide on. This was known as the "pressure-molten water glacial theory." Shaler insisted that in the non-eroded regions the ice in contact with the ground had been liquefied by the pressure above it, in consequence of which there was an absence of any force to drag the pebbles and boulders along the surface of the underlying rock ledges.

Wood totally disbelieved this. He thought he saw a means of disproving it. Harvard, of course, had no apparatus sufficiently powerful for the experiment he wanted to conduct, so he went back to his old friend Sturtevant and to the blower plant. Sturtevant was greatly amused and interested. He gave Wood carte blanche to try anything he pleased.

A large block of cast iron was prepared and bored with an accurately cylindrical hole about two inches in diameter and eight inches in depth. A steel cylinder was accurately turned on a lathe and exactly fitted in the hole in the block to serve as a piston for applying pressure to the ice. The hole was half filled with water, placed outdoors in the freezing weather, and frozen solid. A lead bullet was then placed on the surface of the ice at the center of the hole and the hole was nearly filled with additional water, which was allowed to freeze. The steel cylinder was then inserted and pushed down against the ice, after which it was subjected to a pressure of many tons to the inch, under the mighty ram of the hydraulic press. It was much greater than the greatest pressure that Shaler had imagined in the case of the glacier, equaling the pressure of a body of ice two miles thick.

Under this enormous pressure, paper-thin sheets of ice were squeezed out around the piston, and in some cases needlelike jets of ice spurted up from the surface of the block, the ice

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having forced its way through imperfections in the casting. This escape did not, however, release the pressure, the continued application of which was indicated by the gauge on the press.

On removing the block from the press and warming it up to the point at which the ice cylinder began to melt, it was possible to remove the steel piston and shake out the frozen cylinder of ice. *The bullet was found at the center where it had originally been placed, thus clearly demonstrating that the ice within the cylinder had at no moment existed as "pressure-molten water."*

Wood, though an undergraduate student at Harvard, published these results in the *American Journal of Science* after communicating them to Shaler. Shaler was crestfallen, yet proud of Wood, and completely convinced by the results of the experiment.

The little boy, now grown to daring youth, had returned for a last time to his gigantic toy and had used it to make his first important contribution to scientific knowledge.

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CHAPTER TWO

Four Intransigeant Years as a Student at Harvard—Wood Beards His Professors and Dreams a Dream

FROM the autumn of 1887 until his graduation from Harvard in 1891, young Robert was a difficult problem to most of the faculty with whom he came in contact and conflict. In some studies he was disturbingly brilliant and original; in others he was so indifferent that he narrowly escaped flunking them. It would have been the same in any university. When I asked him how he'd happened to choose Harvard, he said, "Father chose!"

He had entered with the maximum number of conditions. He removed them by taking one or two extra courses each year, but remained a poor student to the end from the viewpoint of those among the academic pundits who discouraged originality—and these were still in the strong majority. By that time, however, Harvard, in response to President Eliot's advocacy of the elective system, had got away from the hard and fast curriculum which forced every student to take a set variety of subjects, mostly classical. Wood was allowed a considerable choice of subjects. These were largely scientific. He specialized in chemistry and would probably have continued in it throughout his life, with his poltergeist-Promethean penchant for fires and explosions . . . if the water closet in a certain later—and supposedly select—boarding-house in Leipzig hadn't opened directly on the dining-room. . . .

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While chemistry was his serious concern at Harvard, his hobby was geology, and the great Professor Shaler said one day to his father, "It's spoiling a good geologist to make a poor chemist." Despite the glacier episode and other wrangles, Shaler remained his best friend on the faculty. Wood admired him deeply, and my guess is that Shaler had a profound influence in shaping the character—and some of the idiosyncrasies —of the future professor of physics. Shaler was a classroom P. T. Barnum, who delighted in dragging in the cherry-colored cats and elephants. As Wood vividly remembers him, he was a red-bearded, long-legged Kentuckian, noted for what the students called "the geological stride," which kept classes at a dogtrot as they followed him on expeditions to the rock-bound coast of Massachusetts or to various inland quarries which they visited. Shaler gave the most popular course in college, designated NH-4 in the catalogue. Its popularity lay partly in the legend that it was a "snap," but there was also an aura about his lecture room which delighted the more intelligent of the students. He was spectacular on occasion to a degree seldom equaled on any stage in the heyday of high vaudeville, and often given to forensic hyperbole. One of Shaler's fantastic flights so intrigued young Wood that after close to fifty years he can still quote it verbatim. It has never appeared in print, and he begged me to include it.

The geologist had been lecturing one day on the gradual development of life on earth; nature's provision of terrifying fertility to insure a species against extinction; the necessity of avoiding overcrowding by the introduction of mass massacre of certain lower forms of life, to supplement nature's own massacres in which species higher up in the evolutionary scale devoured the surplus. Said he by way of peroration:

"The female aphis or common plant louse, gentlemen, produces in a single summer three thousand eggs—gentlemen!—and I have made a calculation that if all the progeny had lived since the first appearance of the Aphididae on earth, we

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should now have a cylinder of plant lice equaling in diameter that of the earth's orbit around the sun, and projecting itself into space with a velocity *greater* than that of light!"

Though our young student was lost in admiration for Shaler's style and vigor, he frequently precipitated violent arguments concerning Shaler's theories and facts. Shaler had a fantastic notion all his own that the earth, long ages ago, had itself spawned the meteors and meteorites which now from time to time come crashing back to us. The astronomical theory, of course, is that they are broken fragments of comets, moving in orbits like asteroids, and that when in the course of their wandering they get entangled with the earth's gravitation, they plunge into our atmosphere, become red hot, and fall to earth in the Siberian forest or in Old Man Jones's cow pasture.

In a lecture one day, Shaler said, "I feel sure it is more reasonable to regard meteorites as volcanic bombs, ejected from great craters erupting here on earth when the earth was younger and more vigorous. These masses of lava were ejected at such velocity that while they were unable to escape completely from the earth's attraction, they were projected in orbits of enormous eccentricity, and instead of falling back immediately, return to our planet only after the lapse of millions of years. . . ."

Young Wood, only a sophomore and a surpassingly intransigeant one at that, had been an "astronomer" since the age of ten. He drew Shaler's attention, after the lecture, to the fact that a velocity of over seven miles a second would be necessary, or fifteen times the velocity of a rifle shell.

Shaler was tolerant, as truly great men are, even in their intolerance, and he and Wood had a long argument about it, but the young student, of course, was unable to shake his conviction in the least. Not even the old Sturtevant plant with its giant machinery could yield any convincing experiment on *that.*

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Professor Jackson of the Chemistry Department was a horse of another color than Shaler. He was one of those "horses of instruction" whom William Blake had in mind when he wrote that the tigers of wrath were wiser. He discouraged original experiment by undergraduates and particularly frowned on impromptu research work in the laboratory.

Wood had read about the compound of iodine and nitrogen which is formed by pouring ammonia upon iodine crystals and allowing them to dry on blotting paper. This compound is a very dangerous explosive, quite harmless when wet, but detonating with a loud explosion upon the touch of a feather when dry. Even a fly lighting upon the powder may cause its detonation. The method of preparing it was so simple that he couldn't resist the temptation to try it in the laboratory, where he was supposed to busy himself only with qualitative analysis.

Iodine crystals were on the supply shelf and ammonia was on every student's desk. It was the work of a few minutes to prepare the explosive compound. Having developed a slight bump of caution from earlier experiments in his boyhood in the manufacture of fireworks and explosive substances for celebrating the Fourth of July, he divided the half-teaspoonful or so of the dangerous substance into quite a number of small heaps on a sheet of blotting paper to avoid the danger of having the whole mass go off at once. One of the smaller heaps appearing to have dried, Wood touched it with a lead pencil. A crack like the report of a pistol resulted and a light cloud of violet smoke floated away from the scene of the explosion. All of the other piles had been scattered without exploding, as they were still in the wet condition. Professor Jackson walked up to his desk and said, "What was that, Mr. Wood?"

"Tri-iodide of nitrogen," meekly answered the embarrassed young student.

"Please confine yourself to the experiment of the afternoon and do not let similar disturbances occur again," said the Professor, coldly.

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"No, sir," replied Wood. Jackson turned away and walked down the laboratory. Presently there was another resounding crack as one of the students stepped on some of the material which had blown off on the floor and dried, and for the rest of the afternoon there were numerous scattered explosions from the scattered particles of tri-iodide. Later Wood discovered that a little of the material laid along the top of the back fence caused surprise to prowling cats.

In those great dawning days of increased academic independence, another member of the faculty at Harvard who did not discourage daring and originality was the immortal William James. Wood took his course in psychology, and carried into that field also a violent curiosity and a tendency toward independent research. One of the requirements in James's course was that each student should write a thesis on some chosen subject. Wood, who disliked rhetorical and dialectic writing and who had barely passed in his course in English composition, cast about for a way to avoid the necessity. It so happened that James at the time was conducting his celebrated "American Census on Hallucinations" and was being swamped with returns to the questionnaires with which he had flooded the country by mail. The census was designed to throw light on what percentage of people "had visions," "heard voices," had premonitions which came true or other unusual psychic experiences. More than fifteen hundred answers had already come in, and he was staggered by the accumulating mass of material which piled up awaiting inspection and analysis. Young Wood was offered—or wangled—the job of collating this instead of doing his thesis. Despite the hard work involved, this was peaches and cream for Wood, who is congenitally possessed with a violent and inordinate curiosity.

This was in Wood's sophomore year, 1888. A good proportion of the hallucinatory responses, of course, were from religious fanatics, while a scattering few were from "dopes." He

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has remembered all these years a rather sweet one that came from a dear old lady in Pennsylvania.

MY DEAR PROFESSOR JAMES,

I often have dreams and visions that have an interpretational meaning, and am a sincere believer that God reveals himself to us now in visions, as he did in the days of Abram and the prophets —but such persons must be pure in heart, thought, and word, and be a total abstainer from tea, coffee, and other stimulants.

Very truly yours,

MRS. J. CUNNINGHAM.

As all who have read *Varieties of Religious Experience* will recall, William James was outspokenly interested in what he termed "the anaesthetic revelation," to wit, the type of visions and hallucinations produced under ether and dentist's gas or by the use of vision-stimulating drugs. Some of the answers dealt with this phase of the subject, and this may partly explain the fact that the young sophomore presently conceived the bright idea of trying a shot at it himself. He had read of the strange illusions produced by hashish, and asked Professor James one day if there was any danger in it. James, who was an M.D. as well as a psychologist, measured his words and replied, perhaps with a smile:

"As a professor in this university, I can hardly give my official sanction to what you seem to be proposing. But as a doctor of medicine, I see no objection to stating that so far as I know there is no recorded case of death from an overdose of cannabis indica, nor is there any evidence for believing that one dose would be habit forming."

So Rob secured and swallowed in due course a suitable quantity of the horrific oriental drug which is supposed to derive its common name from the Old Man of the Mountain and the Assassins. He had read, and correctly, that smoking it, even to excess, produced no actual hallucinations, but merely acted as a narcotic stimulant, as does the sniffing of cocaine.

Wood had dosed himself thoroughly, and had a long series

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of hallucinations, "some horrible, some glorious, magnificent, some filled with the awful grandeur of space and eternity." I am happy to report that he also turned into a fox. Next day he wrote an account of his adventure. Here's the part about the fox, and about a terrific two-headed doll full of pointed prophecy and symbolism:

I next enjoyed a sort of metempsychosis. Any animal or thing that I thought of could be made the being which held my mind. I thought of a fox, and instantly I was transformed into that animal. I could distinctly feel myself a fox, could see my long ears and bushy tail, and by a sort of introvision felt that my complete anatomy was that of a fox. Suddenly the point of vision changed. My eyes seemed to be located at the back of my mouth; I looked out between the parted lips, saw the two rows of pointed teeth, and, closing my mouth with a snap, saw—nothing. . . .

Towards the end of the delirium the whirling images [referred to earlier] appeared again, and I was haunted by a singular creation of the brain, which reappeared every few moments. It was an image of a double-faced doll, with a cylindrical body running down to a point like a peg-top.

It was always the same, having a sort of crown on its head, and painted in two colors, green and brown, on a background of blue. The expression of the Janus-like profiles was always the same, as were the adornments of the body.[1]

He had written his account at the request of Professor James, who included it in his *Principles of Psychology*. In the meantime, Rob had submitted a version of it to the New York Sunday *Herald*, entitled,

KINGDOM OF THE DREAM
AN ACCOUNT OF THE HASHISH PHANTASIA
AS EXPERIENCED BY A NOVICE

It was published in full, September 23, 1888, but he was enraged, and justly so I think, because they ran it simply as a

[1] *Principles of Psychology*, by William James. New York: Henry Holt and Company.

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"letter to the editor," and didn't pay him a penny for it. He wrote to complain and got a specious letter signed by the great James Gordon Bennett in person, saying that since the communication had been addressed to the "editor" it had been published as a letter, and that it was not the custom of the *Herald* to pay for things so used.

I doubt that Bennett had read the piece. I don't think he'd have overlooked the headline possibilities of the fox—Harvard Man Changes into Fox.

Shaler was the only one who gave Robert Wood, Senior, encouragement as to his son's future when a flood of bad marks brought the doctor to Cambridge to inquire personally among the teachers why his boy was doing so poorly. There were two sides to it, of course. Wood felt, not only at Harvard, but later throughout his studies at Johns Hopkins, Chicago, and Berlin, that individual initiative was generally frowned on by professors. In the field of ideas, Wood is an arrogant, at times an impatient, man, and I think he must have been at times an impatient, arrogant youth. I'm not sure he feels that anybody ever contributed very much to him as a scientist. To him the professors might or might not be useful associates in helping to carry out some idea, but he always felt that when ideas clashed, they might be the ones who were wrong. To most of the professors, naturally, he was—like the sheep in the Methodist hymn—"a wandering fox who would not be controlled."

A good deal of light is cast on this by parts of his own notes covering the period, from which I now quote.

To be able to remove a condition in Greek and Roman History by getting a passing mark in Dr. Whiting's course on Color Photography looked to me like robbing a child's bank. I was very poor in the prescribed modern language courses, not realizing that a speaking knowledge of French might add much to one's enjoyment of Parisian café life later on. Nor was I

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good in mathematics; in fact, I was very bad, both in algebra and trigonometry, which struck me as a fearful bore, as no hint was ever given, as far as I can remember, of what possible use you could ever make of sines, cosines, and tangents of angles. Curiously enough I had stood at the head of the class in plane geometry at Mr. Nichols's school. I really enjoyed working out the original theorems, and I can't remember ever having failed to get the solution, though some problems kept me up pretty late at night. There was another boy in the class who was tops in everything, and I worked hard to beat him in geometry, for I was rotten in most everything else. I remember that I worked out what Mr. Nichols accepted as an original solution of the pons asinorum of Euclid. The boy who was tops in *everything* never amounted to *anything,* however.

At Harvard I roomed alone in Thayer 66 the first two years, but at the end of my sophomore year was fortunate enough to draw, in collaboration with a classmate, double room 34 in the newly finished Hastings Hall. Our room had a big bay window on the first floor looking directly down the baseball field. The field was surrounded by the cinder track, so that we and our friends had a private box for all of the spring games. The big window seat had cupboards underneath which could be locked up. Here we stored the liquid refreshments. There was a tea table with cups, saucers, and a brass teakettle, for camouflage. It was occasionally used on Mother's Day or when girls came to the games. We drank beer for the most part, but had sherry and whisky in reserve for jamborees. I drank only moderately, never passed out, and never suffered amnesia. Before reaching that stage, I always felt a strong distaste for anything more, and was having plenty of fun with what I had.

I dined at Memorial Hall, the Student Commons, with the six hundred other sufferers, in spite of the legend that a student had once found a human molar in a plate of beans.

I took no part in college athletics, except as an innocent bystander, until near the end of my senior year, when I sud-

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denly decided to try for the Varsity tug-of-war team, and much to my amazement found myself in place number four just in front of big Higgins, the anchor, whom I next met in England shortly after the armistice of the World War. We trained for a month, and were all set for the Mott-Haven games with Yale, but learned on the eve of our departure that the event had been abolished for good and all, the day before, on account of its dangerous nature. We pulled on a plank walk, lying flat on our sides with our feet braced against high wooden cleats, the rope passing under the shoulder where it was gripped by the heavily rosined armpit of our heavy canvas jackets. The anchor sat with his feet against a cleat and the rope, with one turn around his waist, held in both hands. It was the stupidest contest to watch, as neither team moved forward or back, the only movement visible to the spectators being that of the scarlet rag tied to the center of the rope. Moreover, it was extremely dangerous, many internal and other injuries having resulted from the straining of the muscles to the limit, when practically lashed to rope and wooden cleats. We were listening to "Information Please" on the radio one evening, and a question which stumped every one of the group at the microphone was "What team wins its event by moving backwards?" Of course I instantly said to my family and guests, "Tug of war or boat crew," forgetting at the moment that we never moved at all. "Tug of war" was the correct answer, all the same!

Transportation between Cambridge and Boston was by horsecars, the first electric trolley arriving about 1890, celebrated by Oliver Wendell Holmes in his poem "The Broomstick Train." It took about an hour to get into Boston for the theater or other places of diversion. There was a persistent rumor that Professor Blank was sometimes seen at the "Maison Dorée," and that any student fortunate enough to catch sight of him there was sure of high marks in his course. This may have been an advertisement of the resort designed to attract collegiate custom.

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The course of experimental lectures on electricity given by old Professor Lovering was attended by crowds of freshmen, chiefly because it was well known that a large glass marble, dropped on the top step of the long flight of stairs which led from the bottom to the top row of seats in the lecture hall, would roll slowly to the bottom, going bump, bump, bump. The experiments were apparently those which he had shown in his first lectures, possibly a half century before—dancing pith balls, electrical chimes, electrified wig, etc., many of which I had done years before in the Sturtevant factory. They were amusing, however, and he was a delightful old gentleman, and it was an easy way of removing a condition in Latin composition. My future roommate "took" the electrical course, but never attended the lectures. I coached him for three evenings and he got an A, while I got a B, which shows that he was smarter than I was, for he gave the answers in as few words as possible, while I tried to show off by writing too much, which always infuriates the examiners.

When Rob left Harvard in June, 1891, safely graduated with honorable mention in chemistry and natural history, despite the fact that he had doubtless "infuriated" more than one examiner, it was a relief and surprise to his family—and probably to some of the faculty as well.

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CHAPTER THREE

Alarms, Excursions, and Explosions at Johns Hopkins—Ending in Early Marriage and a Job at the University of Chicago

THE LEGEND that our Promethean poltergeist spat fire and crepitated flames when fate later made him a full professor—as did the unhappy bear beyond the mountain—is not untrue but garbled. The error is merely one of chronology and is readily understandable, since Wood regarded most professors as purple cows and might well have been upset when he became one.

Time embalmed the error when it wrote him up a couple of years ago, and there appeared in print another chronological mix-up concerning the period when he set fire to the boarding-house hash. Both these Pantagruelian episodes occurred actually while he was still a student, doing postgraduate work at Johns Hopkins. He's done even more outrageous things in his full professorial maturity, but it's only fair to keep the record straight.

In the autumn of 1891, after his graduation from Harvard, he went to Johns Hopkins with the idea of taking a Ph.D. in chemistry, working principally with Professor Ira Remsen. The first thing he did was to find a boarding-house to live in—and the next thing he did was to set the hash on fire. There had long been in that college boarding-house an up-to-then unverifiable suspicion that the breakfast hash was made

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from scraps scraped from the boarders' dinner plates the night before. It was a plausible suspicion because morning hash always followed on the heels of steak the night before. But how to prove it? Wood scratched his ear and said, "I think I can prove it . . . with a Bunsen burner and a spectroscope." He knew that lithium chloride was a harmless substance which happened to resemble common salt, both in appearance and taste. He knew also that the spectroscope was capable of detecting the minutest traces of lithium in any material burned in a blue flame. Thus treated, it would show a crimson line. So the fiendish plot was hatched against the landlady, and when next they dined on beefsteak, Rob left some large and tempting scraps on his plate, liberally sprinkled with lithium chloride. Fragments of next morning's hash were pocketed, carried to the laboratory, and cremated before the slit of the spectroscope. The telltale crimson lithium line appeared, faint but unmistakable. The story followed Wood throughout his whole career, and now has a number of international variants. One piece of embroidery places the episode in a German pension to which a distinguished American professor of chemistry was refused admission—because Wood and his lithium had been there first.

The fire-spitting episode occurred one day after a January thaw, as Wood was on his way back from the laboratory to that same boarding-house. The shortest route for the students was through a Negro section which had a grocery store where colored crowds collected every day at noon to sun themselves on the sidewalk. The street just then was flooded with water from curb to curb. Wood had learned that sodium, a soft, silvery metal, when thrown into water, will take fire spontaneously with a loud explosion and burn with a fierce, baleful yellow flame, emitting showers of sparks and clouds of white smoke. The next time he and his fellow-boarders were starting home for lunch, he carried in his pocket, in a small tin box, a ball of sodium about the size of a large marble. The

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big puddle spread in the street, and the Negroes were assembled as usual, sitting on boxes and old chairs in front of the grocery store. As Wood passed, he cleared his throat loudly and spat ostentatiously into the puddle, at the same time flipping the sodium ball, unnoticed, in the same direction. There was a terrific bang as they strode on, sparks flew, and a great flash of yellow fire blazed on the surface of the water. Behind them pandemonium broke loose—howls, prayers, overturned chairs, and one voice louder than all the rest:

"Out o' my way, niggers! Dat man *spit* dat fire! He look young—but only de ole Devil, ole Satan hisself, can do dat!"

Wood says this was his first successful "experiment" with the element which afterward, through experiments of a soberer nature, contributed to his world-wide fame.

A. B. Porter, a graduate student in physics, with whom he had formed a partnership in the perpetration of harmless diversions, collaborated with him in the construction of a giant megaphone, a cone of stiff cardboard nine feet long and about two feet in diameter at the larger end. (Megaphones of this type, only much smaller, were not offered for sale to the general public until four or five years later.) With this they could project speech to an astonishing distance, addressing embarrassing remarks to people two or three blocks away. With a horn of this description one can speak without raising the voice, and the person addressed gets the impression that the speaker is very close to him. Being thus quite safe from detection, they would sit in Wood's room on the top floor of the boarding-house on McCulloh Street and watch for a promising victim. Once they caught sight of a roundsman twirling his night stick and talking to a girl under a corner gas lamp two blocks up the street. Resting the mouth of the great horn on the window sill and pointing it towards the philandering officer, they reminded him in a gentle voice that "All policemen have big feet." To a person walking away from them at the end of the block, with no one else in sight, they would say, "I beg your

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pardon, but you've dropped something." He would stop, look behind him, then down at his feet, then up at the windows above, and after meditating for a moment, move along.

During this year of hell-raising at Hopkins, Wood was conducting a transcontinental correspondence, viva voce, with the girl who later had the courage and audacity to take him on for life. He did this by means of wax phonograph cylinders which they mailed to and fro in old Royal baking-powder cans. He had rented two Edison recording mechanisms (you couldn't buy them in those days) and had taught her to operate one of them. She lived in San Francisco. A priest lived in the room next to his in the boarding-house in Baltimore, and the walls between the rooms were thin. He used to cover his head and the machine with quilts to muffle the ardent words destined solely for the ears of his inamorata.

He had first met Miss Gertrude Ames when he was a sophomore at Harvard. She was a girl out of the Golden West, but of pure New England stock like his own. She had lived in California since her early childhood, but she was born in Boston, daughter of Pelham W. Ames, who was a grandson of Fisher Ames, first Congressman from Massachusetts during Washington's administration. Her maternal grandmother was a sister of Wood's father, so that she was a cousin, once removed. She had come East that winter to visit relatives in Boston and Cambridge. It was her first experience with snow and sub-zero weather. Robert took her tobogganing and sleigh riding. He began his courtship with a bottle of sulphuric acid! "The Courtship of a Coming Chemist" would be a happy title for the episode if it weren't for his absurd antipathy for the Miles Standish word. Here's what I found among his own notes covering that period.

Her hands got cold (on the sleigh ride), and I said, "How would a hot water bottle go?" "Fine," she said, "but where do we get it?" "I make it," I replied, pulling a quart wine bottle

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three-quarters full of cold water from under the seat. Also a bottle of sulphuric acid from which I poured some of the sirupy-looking liquid into the water. In ten seconds the bottle was so hot you could hardly handle it. As soon as it cooled down I added more acid, and when it reached the point at which the acid failed to raise the temperature I produced another bottle containing sticks of fused sodium hydroxide and added these a few at a time. In this way the bottle was kept almost boiling hot throughout our ride.

At the end of his junior year he had spent the summer vacation visiting the Ames family among the giant redwoods at their summer home in Ross Valley. Next winter Gertrude had come East again, this time to visit relatives in New York. Robert took the first train down from Cambridge, and when he returned to Harvard they were pledged for life. Following his graduation he was off to California again for the summer. He had wanted to get married immediately "but father had said no." He entered Johns Hopkins University in the fall, and the wax-cylinder exchange was their way of bridging vocally the gap that separated them temporarily by the width of the whole continent.

In the intervals between the time devoted to this unique correspondence and the conducting of casual chemical deviltries, Robert managed to do a good deal of work under Remsen, and also frequently dropped in at Professor Henry Rowland's laboratory to do odd experiments in spectroscopy and other things more closely related to physics than to chemistry.

Remsen used to reprove him for jumping over the traces, but one such digression, dictated at the time by sheer curiosity, was of real consequence many years later. He'd been working under Remsen in Organic Preparations. One day the task was the preparation of hydroquinone, following the routine formula and directions given in the textbook. (Its white crystals

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are the substance chiefly used for developing photographic plates.) For some reason he doesn't now remember, he sought further information in Beilstein's great treatise on *Organic Chemistry* and was intrigued by the statement that hydroquinone, when oxidized by ferric chloride, yielded something known as quinhydrone, which crystallized "in long, black needles, having a brilliant metallic luster." While this promised no explosions, it promised at any rate a pleasing transformation which Robert's curiosity craved to see. While he was at work on it, Remsen came by, looked at his crystallization dish, and said, "Well, what are you doing *now?*"

"I'm making quinhydrone out of the hydroquinone."

"Well," snapped the great chemist, who, God knows, had followed plenty of divergent lines in his own time, some of which led up blind alleys and others to fame and glory, "you're wasting your time; it would be much better to stick to the prescribed course until you learn the elements of organic chemistry."

Wood made the metallic crystals when Remsen's back was turned, and they were so pretty he put them away like lightning bugs, in a bottle. The curious aftermath came forty years later. A New York doctor claimed to have discovered a mysterious new substance which would prevent sunburn if mixed with a face cream, and had offered it, demanding huge royalties, to the president of a well-known manufacturing company. The latter, with Scotch canniness, unwilling to buy a pig in a poke, and reluctant for that matter to pay for the pig at all if he could help it, managed to obtain a sample and submitted it for analysis to Dr. Wood—who had long since become Professor of Experimental Physics in charge of research in the same sacred halls where Remsen had scolded him. Wood was extremely skeptical that a New York doctor had invented any new chemical substance, despite the fact that members of the Chemistry Department who had volunteered

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to make an analysis of it for him had failed to identify it after several days and had given up the job.

Wood, meanwhile, had been trying it with the spectroscope. The sample was in liquid form, of a light amber color. Photographing its absorption spectrum with ultraviolet light, he had discovered—somewhat to his surprise—that it did indeed eliminate the harmful rays from sunlight. From his knowledge of absorption spectra, his first guess was that it must be a solution of salicylic acid. From his knowledge of chemistry, he knew that if his guess was right, the solution would turn blue when treated with ferric chloride. He tried this—and found his guess was wrong. The mysterious solution remained the same color as before. On the following morning, however, lo and behold, the watch glass on which the test had been made was covered with a crystallized layer of long black needles which shone with a brilliant metallic luster!

"Now where," said Dr. Wood to himself, "have I seen those before?" And since he has the memory of the proverbial Hindu elephant—"Where indeed but in that little bottle put away long years ago when I was but a pup!"

The crystals were the same old quinhydrone, and, *quod erat demonstrandum,* the pig in a poke was no new chemical substance, but the same old hydroquinone used by every photographer—unmasked by what it had done when dosed with ferric chloride.

"So that's what it is," Wood told the cosmetic magnate. "You can buy all you want of it cheaply at any drug supply house—and it does just what that doctor said it would—but if you mix it with any of your skin creams or beach lotions, God help the gals who use it!"

"Why?" said the cold-cream king.

"Because," said Wood, "it's a skin irritant, and photographers use rubber gloves when they mess about with it."

That ended it for the big manufacturer, but later on the New York doctor's "discovery" was promoted by a "beauty

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specialist," and all the women at a certain seaside resort broke out with a frightful skin rash, after which the discovery and discoverer disappeared into oblivion.

In January, 1892, Robert's father died. After due reflection Robert decided to cut short his studies at Johns Hopkins and get married that coming April. In the meantime he had been playing hooky more and more from chemistry, running over continually to Rowland's laboratory in the physics building, and had "bothered Rowland almost to death" trying out all sorts of extracurricular things there. He wanted to spend part of the wedding trip in Alaska, and went over one day to ask Rowland, who had been up there, some questions about Alaskan travel—and incidentally to say good-by and thank him.

Rowland was a gruff great man, laconic.

"What d'you want to find out about Alaska for?"

"Well," Wood said, shifting from one foot to the other, "I'm leaving for California next week to get married, and I want to include Alaska in our wedding trip. . . ."

"Huh," said Rowland with a snort, "tried everything *else*. Going to try *that* now, are you?"

So Robert Williams Wood, no longer Junior, was married to Gertrude Ames on the nineteenth of April, 1892, in San Francisco. He was twenty-four, six feet tall, square-jawed, blue-eyed, dominant, handsome as Lucifer. She was younger, slender, lovely, above the medium in height, with an abundance of honey-colored hair. It was an indissoluble marriage.

Accustomed, both of them, to all the luxuries, they began their wedding journey (via the hotels at Monterey and Santa Barbara) with a camping trip to the King's River Canyon, three hundred miles from any railroad, mostly on horseback, carrying no beds but only their blanket rolls and a tent, with a strange roughneck nicknamed the "Dancing Bear" for guide and packman. He was said to be an English fugitive from justice. He was squat and powerful, less than five feet high,

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with a brown-red beard cut to a blunt point, giving him a bearlike profile. His hands hung nearly to his knees. Reversing Kipling's crack at Russia, he was the man that walked like a bear. As a lady's maid, he must have been a marvel. They started from Moore's Lumber Mills, where they'd obtained the horses and provisions, and went deep into the canyon. They made camp with couches of pine branches and a stove built with stones, lived mostly on bacon, pan bread, and trout from the stream.

Even for his wedding trip, Wood had not overlooked the possibilities of chemical foolishness. One of the chemicals which Remsen's students had to prepare was fluorescein, that remarkable substance, a speck of which the size of a pinhead dissolved in a barrel of water will cause it to glow in the sunshine with a brilliant emerald-green light. Aviators shot down in the ocean in the present war are using it to create an enormous green spot on the surface of the water, easily seen by rescue planes.

The Yellowstone Park, which he had visited the year before, was to be included in the itinerary, and it occurred to Wood that Old Faithful geyser would be a real spectacle if heavily charged with fluorescein. So he made a pint of the material in the form of a thick dark-brown sirupy mass, tightly corked in a wide-mouthed bottle, enough to make a small lake fluorescent, and stored it in his baggage.

On the way East, after adventures from California to Alaska and back, they made the grand tour of the Yellowstone, and Wood got ready for the geyser with his bottle of fluorescein. Of this episode, he says:

We found Old Faithful too well watched by the guards to accomplish anything there, but I remembered an even better spot, the celebrated Emerald Spring. A big party of tourists with a guide was about to start on foot for it, but I knew the

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way and we two started ahead of them, and found the great spring deserted. A strong flow of water was coming up from the depths of the funnel, and as soon as we heard the voices of the tourists, I uncorked the bottle of fluorescein and threw it into the center of the pool. Down it went deeper and deeper until it was lost to view, leaving a green trail to mark its path. Nothing happened for a minute or two, and then there rolled up slowly from the depths a great cumulus cloud like a thunderhead of a dazzling green color, which grew larger and more complicated in form as it neared the surface, and by the time the tourists arrived, the whole pool was glowing in the hot sunshine with the brilliance and color of an emerald. We heard the guide intoning monotonously his patter: "This here, ladies and gentlemen, is the Emerald Spring, so called from the greenish color of—my God, I've never seen it like this, and I've been here ten years!" The tourists were entranced, and so were we.

Since marriage had increased his expenses and responsibilities, and since he was a practical New Englander despite his fantasies, the young man began looking around for some not too costly way of continuing his studies. The then newly formed University of Chicago suggested itself to his mind. It was being publicized as the most lavish academic set-up of all time. Rumor had it that the catalogue weighed fourteen pounds, and that it contained reference to three courses in chemistry—all devoted to compounds which didn't even exist! So Wood applied for a job, and got it in the autumn of 1892, after what I would call his honeymoon. (He detests the word. His notes which covered that happy period are entitled "Travel Subsequent to Marriage.") He had asked to become an assistant in chemistry and was appointed honorary fellow in chemistry. It was really a job as "bottle washer for Stokes," he says—and the honor carried with it no honorar-

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ium. All it did was to give him free access to the laboratory. I want to quote at not too great a length from his notes covering the next couple of years, though there's scarcely any mention in them of the laboratory, or of the university either for that matter. I quote because I think they throw, between the lines, additional light on his character. I have never known exactly what the phrase "practical joke" means, but I do know that a lot of practical jokers deserve to be killed with an ax. Now Robert Williams Wood, from early childhood and today in his honored maturity, plays pranks which are sometimes appalling. But there is a curious mingling of deviltry and kindness in the man which has kept him not only admired but loved by most of his butts and victims. I'm told, not by him, that their old Irish maid Sarah, for instance, viewed him as a benevolent if eccentric demigod. Here are a couple of pages lifted from his own notes on Sarah.

We took a "flat," as it was called in those days, in an apartment building on the South Side. The Chemistry Department was housed temporarily in a new and very unpretentious apartment house, the rear windows of which commanded a fine view of the rising buildings of the World's Columbian Exposition. We were just opposite the great Ferris wheel, and watched its growth from birth.

Gertrude was lucky in her choice of a maid of all work, a tall gaunt Irish girl of some forty summers who was a splendid cook, but eccentric. Sarah was innocent as a child of ten and faithful as an old plantation darky. I had bought a tricky apparatus designed to gull the gullible. It was called "The Magic Money-Maker." A long strip of black cambric was wound up on two parallel rollers, one of which could be turned by a crank, winding up the cloth from its neighbor. You loaded up one side with new five-dollar bills and by feeding strips of white paper in succession between the rollers, out

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came the bills. It was a perfect optical illusion. I showed it to Sarah, who viewed it with open eyes. Later she came to me holding out an old dollar bill that had been torn in halves and asked hopefully, "Wud the machine mend it?"

"Oh, yes," I said—and then I remembered that the machine was loaded with five-dollar bills—"but you'll have to wait a minute as I have to change it for mending." I couldn't find a one-dollar bill in the house for some time, but finally located a fairly new one in an old pair of pants. Slipping this into the machine, I was ready for Sarah, and as the torn bill slowly passed into the little black "clothes wringer," out came a fairly fresh bank note. She was enraptured, rushed off to her room, and presently reappeared with a frayed, moldy, and partly torn document. "An' cud yer do anything with this, Mister Wud?" "What's that?" I asked. "Well, yer see, Mister Wud, whin I was leavin' off wurkin' for Mrs. Jones in Kansas City, the where I'd bin wurkin' for her for tin years, Mister Jones, who was in the lumber business, said for me not to be puttin' the sivin hundred dollars I'd saved up in the savin's bank, the where I'd be loosin' it, but to invist it in his business where it wud be safe, and he'd be givin' me six per cent, the while the savin's bank wud be givin' me only three per cent—so I give it to him and he give me this paper." "Have you ever asked him to return the money?" I asked. "Oh, no," she said, blushing, "I'd not be after naydin it unless I'd be gittin' married."

"The machine is no good for fixing your paper," I said, "but if you'll give it to me I'll see what I can do for you. I'm afraid, though, you may never be able to get your money back." Sarah burst into tears, and Gertrude tried to comfort her. The paper was a promissory note properly executed, and I took it downtown to my bank. "Pretty hopeless," the paying teller said, "but we'll send it in for collection and see what happens." Within a week I was informed that it had been promptly paid with interest to date, and I took Sarah down to the bank, in-

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troduced her to the teller, and had her deposit it all in the savings bank. Good old Jones of Kansas City, I take off my hat to you!

Revelatory too, I think, is Wood's own description of an evening he spent with a multimillionaire lumber king isolated in the wilds of Wisconsin—whose passion was astronomy. Taken with all its implications, it is a rather beautiful and to me unforgettable story. I should like to have been there that night when Rob was young, nearly fifty years ago.

Here is Wood's account.

One summer when the term was over we wanted to get out of Chicago before the hot weather, on account of the baby, and so with old Sarah promoted temporarily to the position of nurse, we started off for Twin Lakes, a remote fishing resort in northern Wisconsin. Our itinerary called for a change of cars at 7:00 P.M. at a railroad intersection. The station was of the boxcar type, and no other house was in sight, nothing but pine woods. As our little train steamed away into the darkening forest we looked for the other train which was to carry us on our way, but there was nothing in sight. The old codger who was ticket agent, telegraph operator, freight and baggage man—and tout for the only hotel in the place, as we learned presently—told us our train didn't go until next morning, but that there was a hotel up the road a piece.

Gertrude said, "You go along and explore, because it may be worse than the station."

The baby was crying as I left, and the outlook seemed unpromising, for we were in a wild, unbuilt-up lumber district. Up the hill a few hundred yards away, the hotel loomed through the trees, a huge old ramshackle building with most of the weather-beaten blinds hanging askew on a single hinge. Many windowpanes were broken, and all the rooms in the two upper stories dark. But on the ground floor things were

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pretty lively. It was Saturday night and the lumberjacks had their weekly pay envelopes. There were bright lights, the sound of a hurdy-gurdy piano, and the thud, thud of lumbermen dancing in heavy boots; men were three deep along the bar, and others of less gay appearance were absorbed in poker. It offered dubious night's lodging for a young mother and baby. I went away from there and moved along up the road, coming eventually to a high fence which appeared to surround some sort of an estate. There was a lodge or office at the gate and a cue of fifteen or twenty evil-looking men waiting for their pay envelopes, which were being passed out through a window. After the line had been attended to, I approached the window and explained my predicament. The young paying teller told me to come in and sit down, he would see what could be done about it. He was back again in a few minutes with the information that I was to bring my family; that Mr. S—— would take care of us. I hurried back to the forlorn little group sitting on a baggage truck with the news that we were to be house guests of the big boss.

We presently found ourselves being admitted to a mansion by a manservant who announced that dinner would be served in fifteen minutes, and would we like to be shown our room in the meantime? Sarah and the baby had been spirited off to another part of the house.

Downstairs in the dining-room we found prepared for us a splendid dinner of broiled steak, fried potatoes, corn fritters, fruit, and coffee—but no sign of our host. Later, after Gertrude and the baby were safely upstairs, he appeared with a box of cigars and suggested we go out on the lawn where it was cooler. Drinks were brought presently, and it turned out that he was an amateur astronomer! It was a clear night and the stars fairly blazed. He asked question after question and I told him everything I knew—how they measured the velocity of the stars in space by the shift of the lines in the spectrum, about the nebular hypothesis, why some comets return

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and some do not, and matters of that sort. Every time I suggested bed, he poured another round of drinks and pushed over the box of cigars. It was three o'clock when we finally turned in. He did not appear at breakfast next morning. After a slight delay due to some eccentricity of the baby, we were driven in state to the boxcar station, where we found that the train was being held for us by the request of our host!

Later we learned that he was the "lumber king" of Wisconsin. It was my first meeting with an American captain of industry, or tycoon, as he would now be called. He was truly interested in astronomy, and had said a thing so extremely gracious it embarrassed me. When I thanked him for his hospitality, he had quoted the line about "entertaining an angel unaware."

Wood's official "job" at the University of Chicago was confined largely to cleaning up apparatus after Professor Henry N. Stokes's lectures, and he presently resigned that appointment in favor of the janitor. Here is Wood's own description of what followed.

Professor E. A. Schneider, a German, captured me for "research work," suggesting what he described as a very interesting line of work on titanium. The first stage of the "research" was the preparation of a large quantity of potassium titanofluoride, a chemical that was not on the market. I would need a platinum dish and some of the mineral rutile, which he said he would order for me. The dish turned out to be as big as a finger bowl, and cost three hundred dollars, which I had to pay out of my own pocket, and there was about twenty pounds of rutile, which I had to pound in a mortar and pass through a fine sieve, until the whole mass was reduced to a powder as fine as pepper. It took about two weeks, and the black powder got in my hair and my nose, and over my clothes. Then came several weeks of work in fusing a mixture of potassium

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carbonate and the powder in the platinum dish, treating the mess with hydrofluoric acid, and crystallizing the product. I began to chafe over the monotony of going through this process over and over again, but Schneider kept me at it until the whole mass of rutile had been converted into the double salt. I said, "Well, what do we do now?" and was told that nothing more was to be done on the problem at present, and he would give me something else to do in the meantime. I smelled a rat, or I might more properly say a skunk, and spoke to Dr. Lengfeld about the work. He intimated that he thought I would make more progress if I took a real problem instead of serving as a manufacturer of chemicals.

So I left Schneider, who appropriated the large bottles of the preparation on which I had spent so much time and money. Later on I was told that he probably wanted it for some of his own work, and he even offered to take the platinum dish off my hands for half price, but that didn't work. I started work under Felix Lengfeld's direction and gradually forgot the unpleasant experience. Schneider left the university a year or two later. Years later, looking through the volumes of the German periodical, *Anorganische Chemie,* I found a paper by Schneider on the chemistry of titanium, in which he stated that he employed as his basic material the compound potassium titanofluoride, with no acknowledgments or statement of where he obtained it. He just took it out of a hat, like a rabbit. I kept the platinum dish for several years and eventually sold it for more than I had paid for it.

After my routine with rutile, I started a more interesting piece of work under Dr. Lengfeld's direction, and published two papers in the *American Chemical Journal.* I reported the results of my research work at the weekly meeting of the Chemistry Colloquium, and felt a little nervous, as it was the first time that I had appeared before a critical audience. The subject was rather technical, and I had formed a resolve never

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to "read" a paper. It went off fairly well, and I found that embarrassment faded away rapidly as I went on.

Shortly after, I was asked to give a popular lecture with experiments, open to the public in the auditorium of the new Kent chemical laboratory. I chose as a subject "The Vortex Atom Theory," propounded first by Lord Kelvin, and later developed by Professor Helmholtz of Berlin, which was receiving some attention by chemists at the time. I chose this subject chiefly because I wanted at least one spectacular lecture experiment that would make the audience sit up, and I decided that a huge "vortex machine" for making smoke rings would fulfill the requirements. I made a big one, bigger than I had ever seen, a cubic wooden box four feet on each edge, one side made of flexible thin oilcloth, loosely tacked on, with two diagonal strips of rubber tubing behind it, firmly attached to the corners. At the center of the opposite side was a circular hole about a foot in diameter. On striking the center of the square of oilcloth a smart blow with the fist, an invisible ring of air was shot from the box with such velocity and momentum that it would knock a large pasteboard box from the end of the lecture table onto the floor, while the impact on the face or body felt like a mild blow from a feather pillow. By filling the box with smoke produced by mixing the vapors of ammonia and hydrochloric acid, the rings were made visible, and the classical experiments with them could be shown on a large scale. With a little practice, two rings could be fired in rapid succession: the second ring, with a higher velocity, would catch up with the first and bounce off it, both rings remaining intact and changing into vibrating ellipses. This showed that a gas in rapid rotation had some of the properties of a solid (elasticity, for example). The "vortex atom" theory supposed that chemical atoms were endless vortices in the "ether of space," tied in complicated knots, for it had been shown that if two or more vortex rings of a frictionless fluid were linked together or tied in knots they would spin forever,

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without interfering with each other or coming to rest. I had some other experiments which I've forgotten, but the big box came at the end of the lecture. When it was pointing skyward an invisible ring of air splashed against and extinguished the greater part of the circular ring of gas flames at the center of the auditorium dome. Two or three always remained lit, and the fire then ran around the entire ring, so that the experiment could be shown over and over again as fast as you could thump the box. Then I commenced a Blitzkrieg on the audience, shooting powerful invisible rings at the sea of faces. The spectators were delighted and applauded loudly, and I finally took courage and fired a ring at Mrs. Harper, the wife of the President, which lifted the front of her broad-brimmed hat several inches, and then one into the broad, smiling face of the President himself, who winced.

We now come to the early spring of 1894. Wood had finished a piece of research acceptable to the Department of Chemistry as a thesis for the Ph.D. degree, and the examinations were in the offing. He was, however, suddenly informed that he would be required to pass examinations in advanced physics and mathematics if he wished to come up in physical chemistry. This change in the requirements had resulted from the advent of A. A. Michelson as head of the Department of Physics. Wood had a long and somewhat heated argument with President Harper, claiming that he had not been told this in the beginning and was not well enough prepared in either subject to take examinations on such short notice. Harper overruled his objections, and Wood left the university early in May.

He had definitely decided anyway, at this time, to go to Germany with his family, to work with Professor Wilhelm Ostwald, then the world's leading physical chemist. But it was necessary to put off the trip because of the imminent arrival of their second child.

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Accordingly, the Woods packed up, stored their furniture, and went out to San Francisco to visit Gertrude's parents. Robert Wood, Junior, was born on June 23, 1894, in his grandmother's house.

After an interval for Gertrude's recovery, both the Woods began to study German furiously. Their first tutor was a red-bearded young German, with a facetious manner and a craving for Mr. Ames's best cigars. His visits resembled social calls, and in fact, since he preferred to talk in English, the German lessons were a flop. It was difficult to get rid of anyone so polite, however, and finally Wood hit on a way of getting rid of the man. He substituted a trick cigar for one of Mr. Ames's Coronas. And when Herr Becker, at the next lesson, lighted it, there was a bang. It had exploded.

Their next teacher was a Frau Lilienthal, who was excellent. She gave them a letter to Professor Leo, Germany's foremost Shakespearean scholar, who afterwards proved very hospitable to the Woods.

Late in the summer of 1894, the Woods started East with the two children, Margaret and Robert, Junior, bound for Berlin.

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CHAPTER FOUR

Escapades and Studies in Berlin—Wood Sits In at the Birth of X Rays and Takes to the Air in a Glider

THERE turned out to be only one water closet in the Leipzig pension where Wood, wife, and babies were to live while he studied chemistry with Ostwald. Moreover, it opened directly off the dining-room! Robert says his father "chose" Harvard for him, and there's a story that it was Mrs. Wood, influenced by this open plumbing openly arrived at, who "chose" to go on to Berlin.

My own impression is that nobody ever successfully "chose" anything for Wood unless it chanced to coincide with his own choice. Anyhow, wife, babies, bags and baggage, they went to Berlin.

What seems to have first struck and stimulated Robert's best —or worst—instincts in the German capital was the abundance of signs, placards, and police injunctions indicating that many trivial personal actions, free in democratic countries, were here either forbidden or state controlled. He had known, of course, about the *Verboten* placards, but not about the *Strengstensuntersagt* ones. They translate literally "strengthily undersaid," and while Robert insists they merely amused him, I suspect they had the same effect a red flag is supposed to have on the proverbial bull.

The first one he saw was over the window of his compart-

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ment in a railway coach, framed under glass in a neat oval bronze frame. It read:

DAS HINAUSLEHNEN DES KÖRPER
AUS DEM FENSTER, IST WEGEN
DER DAMIT VERBUNDENEN LEBENS-
GEFAHR STRENGSTENS UNTERSAGT

("The leaning out of the body out of the window, is on account of the thereby intimately-bound-up-life-danger strengthily undersaid.")

He improvised a screw driver, removed the placard, frame and all, put it in his pocket, and subsequently hung it in his room, to study the last two words if and when inspiration flagged. He went out and bought boomerangs, and began throwing them. He rolled rocks down neighboring German mountainsides, creating miniature avalanches. He made flights in Lilienthal's glider. He set up a huge camera in the street and photographed a cesspool pump in action, under the impression, pretended or real, that he was photographing the Berlin Fire Department.

Richard Watson Gilder, then editor of *Century,* had been equally stimulated by *"Strengstens untersagt,"* and had written a poem about it. Young Wood learned the poem by heart and frequently declaimed it at dinner parties. The first two stanzas run:

A Yankee in Deutschland declared
"I know a fine Fraülein here,
Of the Bangor girls she's the peer.
We'll go and at once be wed."
"Oh no" said the Polizei.
Said the Yankee "Why?"
"You cannot at once be wed
It is strengthily undersaid.
You first must be measured and weighed and then
Tell where you were born and why and when."

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"Oh well" the Yankee declared,
"We'll go instead for a spin
On our bike through the beautiful streets of Berlin."
"Oh no" said the Polizei.
Said the Yankee "Why?"
"You cannot go wheeling instead
It is strengthily undersaid.
You first must be measured and weighed and then
Tell where you would wheel and why and when."

Robert made up another stanza concerning his own *Kinder.* You had to license and put a number plate on the *Kinderwagen* (baby buggy) since it was "a vehicle on four wheels."

Our young father of buggy-licensed babies had meanwhile, of course, begun his studies in the chemistry department at the University of Berlin. After some time spent, however, in dull routine and the working out of "some particularly stupid problems," he began to drift more and more, as he had at Johns Hopkins, into the physics laboratories and lectures, to see what was happening there. Things looked more exciting, and after talking with Professor Rubens, who spoke perfect English, Wood took the plunge: he was definitely tired of physical chemistry and decided that physics would be his field.

He was told he could not start on research until he had performed *all* the preliminary experiments of the *Kleine Practicum,* which corresponds to undergraduate laboratory work in America. They were willing, however, to take his word that he had already done all but some half dozen of the experiments. The first experiment they required him to make was the accurate determination of the time of oscillation of a torsion pendulum, i.e., a large metal disk, suspended at its center by a wire, which slowly rotates first to the right and then to the left. On reading the instructions and thinking over the matter, Wood decided he knew a better method. On trial it proved to be simpler and more accurate than the classical one in use in the laboratory. Professor Blasius, who directed the work, was so much impressed that he asked Wood to write

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a paper on the subject; and Professor Warburg, the Director of the Physical Institute, approved its publication in the *Annalen der Physik.*

Thus Wood's formal entry into the field of physics was marked by an example of the experimental daring that was to characterize all his future work. He continued to experiment on the side; and two papers of his—one on a lecture method of showing the nature of optical "caustics" and the other an ingenious method of determining the duration of the flash of an exploding gas—were published in the *London, Edinburgh and Dublin Philosophical Magazine* (commonly known as the *Philosophical Magazine,* or, more intimately, as *Phil. Mag.*), which was the leading English-language review in physics.

But the most exciting scientific event of Wood's Berlin days was to come. Here is his own account of it:

One memorable morning in the early winter of 1895 Professor Blasius came to us in great excitement. "Come this way, something very wonderful has just been received." We hurried along after him into one of the smaller rooms, where hanging on the wall were half a dozen or more strange-looking photographs, a life-size human hand with all of the bones clearly outlined, a purse with a number of coins inside, a bunch of keys inside a wooden box, and other objects. "What in the world are they?" we asked. "They just arrived," he replied, "in the *Geheimrath's* morning mail. Professor Roentgen of Würzburg sent them. They were made by some new kind of rays that penetrate most opaque substances and cast shadows on the photographic plate of metals and other dense materials. He calls them X rays, because x represents an unknown quantity in algebra, and he has no idea what they are. They come from the glass wall of a vacuum tube, where the cathode rays strike it."

Later in the day Warburg came to my room holding in his

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hand the little ten-page reprint of Roentgen's paper, asking me if I cared to read it, and if so, to please leave it on his desk after lunch. The pages had not been cut, so I cut them up the side and along the top, read the paper, and left it on his desk.

Early in the afternoon he came to my room in a rage. "Herr Wood, why have you cut these pages?" going on to say that he had borrowed the reprint from the newsstand on the corner (they were on sale all over Berlin, at ten cents a copy), that Roentgen would send him a copy, and that now he would have to pay the news dealer, as I had spoiled the copy by cutting the pages. I said that he had suggested that I read it, and that I couldn't very well read it without cutting the pages. "Why not?" he replied. "You can read it this way" (holding his finger between the pages, spreading them apart, and peeking in from the bottom). "That is what I did." I said I'd be delighted to pay the news dealer and keep the copy myself. "Good. You can do that," he beamed. I still have the reprint!

Within a day or two the laboratory was humming with the buzz of the vibrating spring interrupters of every Ruhmkorff induction coil that could be found in the instrument cases. Everyone who could blow glass and had access to an air pump was busy making the pear-shaped glass bulbs, sealing in electrodes, and laboriously exhausting them with cumbersome mercury pumps, which were all that we had at the time. The laboratory had gone X-ray mad. We photographed our hands, mice, small birds, and all sorts of things. I wrote a long story of the discovery, illustrated with photographs, and sent it to the leading Chicago newspaper. This was the first account to reach America, with the exception of a five-line cable. It was returned by the editor saying that they had already published a full-page story in the Sunday issue, illustrated with photographs made by a South Side photographer, who had antedated and beaten Roentgen—he had photographed the insides of a piano through the case, the vitals of a typewriter

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through its tin cover, and other impossible subjects, all transparent fakes of course.

I remailed the article immediately to the *Century Magazine;* it appeared in the next number, and even with this long delay it was the first comprehensive communication on Roentgen's discoveries to appear in America.

When the required laboratory experiments were finished, it was customary for the newcomer to ask some professor's help in choosing a subject for research. But one or two ideas had occurred to me while reading, and I had found a corner in the attic of the laboratory that was ideal for private experiments. It was roomy and out of the way. Moreover, it was a storeroom for old apparatus and barrels full of discarded vacuum tubes and glass bulbs used by the celebrated Goldstein, some of whose discoveries on the discharge of electricity in high vacua had antedated those of Crookes in England.

I hunted up an old induction coil and storage battery and played for a few days with some of Goldstein's old vacuum tubes, often reading his papers. Nothing was known at the time of the nature of electrical discharges in gases at low pressure, and there was much discussion about the temperature of the luminous gas in vacuum tubes, which had never been determined experimentally by a method free from objections. The typical discharge in a long glass tube containing, say, hydrogen gas at low pressure, and furnished with wire electrodes at each end which carry the current from a high potential storage battery of many hundred small cells, is a rose-colored column of light, broken up into disk-shaped stratifications, extending two-thirds of the way down the tube from the positive electrode, then a dark space in which the gas is nonluminous, though obviously carrying the electrical current, and finally a blue glow extending out from the disk which forms the negative electrode but separated from it by another and very narrow dark space. An unsolved question was the

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distribution of temperature in this complicated discharge. Were the luminous parts hot and the dark spaces cold, or was the temperature sensibly the same throughout the tube?

I told Professor Rubens I should like to investigate this question and thought that it could be done with a bolometer arranged in such a way that the instrument could be moved along the discharge when the tube was excited. The bolometer measures temperature by the change in the resistance of an exceedingly fine platinum wire when heated, and therefore requires two wires leading to a galvanometer and battery. "And how then will you move a bolometer about inside a vacuum tube?" asked Rubens. I thought it could be done by mounting the discharge tube on the top of a barometer tube, with the bolometer wire on the upper end of a narrow glass tube carrying the two wires and passing up through the mercury column of the barometer. The open end of the barometer tube was to dip into a tall glass jar filled with mercury, and the narrow tube, carrying the bolometer at the top and bent into a long U at the bottom, passed down through the mercury column and up through the jar into the outside air. By raising or lowering the exposed arm of the U, the bolometer could be made to traverse the discharge tube. Rubens thought the idea good, and spoke of it to Warburg, the director. I was given a small room to myself, with an air pump for exhausting the tube or changing the pressure, and the necessary electrical equipment. I found an old Goldstein tube in the attic, which was exactly what I wanted, and started setting up my equipment.

The investigation with the movable bolometer occupied me for the better part of three semesters, and turned out even better than I'd hoped, for I was able not only to measure the temperature in the main parts of the discharge but also to record its slight rise and fall, as the bolometer loop of thin wire passed through the luminous disks of the stratifications.

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This method of exploring the interior of vacuum tubes became standard practice and has been used in many subsequent investigations by others.

Wood's account of the Berlin period is not confined entirely to laboratory research. There are two colorful spots, one having to do with getting stuck on a pinnacle during a vacation rock-climb in Switzerland, and the other telling of adventures with the ill-fated Lilienthal and his glider. The rock-climb comes first, and here's what he wrote about it:

I'm no mountain climber, much less a rock-climber, but when we went up from Interlaken to the Schynige Platte, which commands a marvelous view of the Jungfrau, Mönch, and Eiger, I was intrigued by a curious rock rising like the tower of an old castle and aptly named the "Gummihorn." It was gray in color and resembled old, rotten rubber.

Baedeker said its summit had been recently made "accessible to experts." It rose abruptly from a green hill only a few hundred yards from the hotel, and I decided to have a look at it after lunch. It was about a hundred and fifty feet in diameter at its base and perhaps three hundred feet high, the walls being practically perpendicular. Finding a place with a slight incline from the perpendicular I commenced to crawl up, finding numerous toe and finger holds. About half way up I found myself standing on a narrow ledge possibly ten inches in width, and faced by a smooth perpendicular wall about six and a half feet high. A bit of rope hung over the edge, and I could see that the other end was fastened to an iron spike driven into the rock of a second ledge above me. This evidently represented Baedeker's "recently made accessible." Clinging to a crevice with my left hand, I took hold of the rope with my right and gingerly pulled. As I pulled harder, it broke at the point where it was in contact with the sharp edge of the rock. I nearly let go with my left hand, but

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managed to keep my hold. I looked down. The grass looked pretty far away, and I began to doubt whether I could find the toe holds for descent. Finally I decided to climb on to the top and be rescued by the fire department. I managed to pull myself to the next ledge by means of the iron spike, and from here on to the top found the climbing easier. A group of Germans on a neighboring hill raised their hats on their Alpine stocks and shouted *Hoch! Hoch!* when I appeared on the summit, but I was too much shaken to do more than give an indifferent wave in return. I managed to get down by a slightly less difficult path. It was comic-opera mountaineering in miniature.

We had planned to walk back to Interlaken, but Gertrude was tired and elected to go by train. I had observed that I could save a long walk around the edge of the mountain if I walked through the railway tunnel. There was a large sign saying that traversing the tunnel on foot was "strengthily undersaid" and punishable by a heavy fine. It got darker and darker in the tunnel, and I could walk straight only by trailing the bottom of my Alpine stock along one of the rails. Then I heard behind me the chug-chug of the little locomotive, which carried no headlight. I was really scared, and hurried along stumbling over the ties in the darkness. I seemed to be holding my own with the little engine, however, and presently emerged from the tunnel—almost into the astonished arms of two uniformed guards or policemen. I tried to pass with a cheery *"Guten Abend,"* but one of them seized me, swung me around, and said I was under arrest.

There was a high perpendicular cliff on one side of the track and an exceedingly steep declivity of loose stones or talus on the other. As the policeman released his hold on my arm and began talking excitedly to his companion, I said angrily, in my best German, "I am in a great hurry and have no time to be arrested," and leaped over the edge of the embankment astride my Alpine stock. Holding the top in both

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hands and trailing the rest behind me, and paddling with both feet, I slithered down at terrific speed, like a witch on a broomstick, followed by an avalanche of loose stones. Reaching the bottom of the talus slope where the pine forest commenced again, I glanced back and saw the train had stopped and the two policemen were climbing on board. Realizing I was now a fugitive from justice as well as a tunnel "crasher," I ran down the mountain, cutting across the zigzags of the trail and jumping over logs and boulders. I reached Interlaken well ahead of the train, and sought the sanctuary of my hotel.

Wood was present as a friend at the last successful glider flights made by Otto Lilienthal, which took place only a few days prior to the crash that caused the inventor's death. I scarcely need to tell you that Wood himself insisted on making a flight in the glider too—and did so successfully. Lilienthal was the first man to navigate the air for any distance without the aid of a balloon. Wood made the last photos ever taken of his flights, and still has the letter Lilienthal wrote on Saturday, August 8, 1896, inviting him to come along next day—which proved to be the ill-fated day on which the glider crashed.

Wood wrote an article for the Boston *Transcript* on this experience, from which he has prepared the following account.

It was near the end of my two years in Berlin that I made the acquaintance of Otto Lilienthal, whose pioneer work on artificial flight I had followed with interest for years. His early experiments, based on a long study of the flight of birds, had been performed in the outskirts of Berlin, where he had built a small artificial hill, from the top of which he had launched himself supported on wings of bamboo and cotton fabric, gliding off to a landing at some distance from the base of the hill. By this time he had become more ambitious, and practiced his flights on the high rolling hills near Rhinow, some of which were over three hundred feet high and car-

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peted with long thick grass and spongy moss. Before taking me out to witness his flights, he showed me, in his engine factory in Berlin, a power-driven aeroplane, with twenty-five square yards of wing surface, which was almost completed. On the following Sunday we went by train to Neustadt, some hundred miles north of Berlin, and from there to Rhinow in a peasant's cart. Storks were flying over the fields all around us, frequently landing close by the roadside, and Lilienthal excitedly explained how they landed, by swinging their long legs out in front just before reaching the ground. This movement threw up the forward edge of their wings and arrested the forward motion. He had learned how to imitate this technique, after many accidents involving sprained ankles and broken bones.

His machine was a "pocket airship," and was stored on a small cart in the peasant's barn. We drove over to the mountains, and with the help of the peasant the "glider," as we should call it now, was put together like a box kite. It was a biplane with wings having arched surfaces, which he had discovered were very superior in lifting power to flat surfaces.

The lower plane measured twenty feet from tip to tip and the upper one, supported on two stout bamboo sticks, was firmly fixed to the lower by tightly stretched guy wires. So perfectly was the machine fitted together that it was impossible to find a single loose wire or brace, and the whole machine "boomed" like a drum when rapped with the knuckles. We carried the machine to the top of the hill, and Lilienthal took his place in the framework, lifting the wings from the ground. He was dressed in flannel shirt and knickerbockers, the knees of which were thickly padded to lessen the shock in case of a too rapid descent, for in such an emergency he had learned to drop instantly to his knees after striking with his feet, thus dividing the collision with the earth into two sections and preventing injury or strain to the machine.

I took my place considerably below him, by my camera,

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and waited anxiously for the start; he faced the wind and stood like an athlete waiting for the starting pistol. Presently the breeze freshened a little; he took three rapid steps forward and was instantly lifted from the ground, sailing off nearly horizontally from the summit. He went over my head at a terrific pace, at an elevation of about fifty feet, the wind playing wild tunes on the tense cordage of the machine, and was past me before I had time to train the camera on him. Suddenly he swerved to the left, somewhat obliquely to the wind, and then came what may have been a forerunner of the disaster of the next Sunday. It happened so quickly and I was so excited at the moment that I did not grasp exactly what happened, but the apparatus tipped sideways as if a sudden gust had got under the left wing. For a moment I could see the top of the aeroplane, and then with a powerful thrust of his legs he brought the machine once more on an even keel and sailed away below me across the fields at the bottom, kicking at the tops of the haycocks as he passed over them. When within a foot of the ground he threw his legs forward, and notwithstanding its great velocity the machine stopped instantly, its front turning up and allowing the wind to strike under the wings, and he dropped lightly to the earth. I ran after him and found him quite breathless from excitement and exertion. He said, "Did you see that? I thought for a moment it was all up with me. I tipped so, then so, and I threw out my legs thus and righted it. I have learned something new; I learn something new each time."

Towards the end of the afternoon, after witnessing perhaps half a score of flights and observing carefully how he preserved his equilibrium, I managed to screw up courage enough to try the machine. We carried it a dozen yards or so up the hillside, and I stepped into the frame and lifted the apparatus from the ground. My first feeling was one of utter helplessness. The machine weighed about forty pounds, and the enormous surface spread to the wind, combined with the leverage of

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the ten-foot wings, made it quite difficult to hold. It rocked and tipped from side to side with every puff of air, and I had to exert my entire strength to keep it level.

Lilienthal cautioned me especially against letting the apparatus dive forward and downward, when the wind strikes the upper surface of the wings—the commonest disaster the novice meets with. The tendency is checked by throwing the legs forward, as in landing, which brings the machine up into the wind and checks its forward motion. As you stand in the frame your elbows are at your sides, the forearms are horizontal, and your hands grasp one of the horizontal cross braces. The weight of the machine rests in the angle of the elbow joints. In the air, when you are supported by the wings, your weight is carried on the vertical upper arms and by pads which come under the shoulders, the legs and lower part of the body swinging free below.

I stood still facing the wind for a few moments, to accustom myself to the feeling of the machine, and then Lilienthal gave the word to advance. I ran slowly against the wind, the weight of the machine lightening with each step, and presently felt the lifting force. The next instant my feet were off the ground; I was sliding down the aerial incline a few feet above the ground. The apparatus tipped from side to side a good deal, but I managed to land safely, much to my satisfaction, and immediately determined to order a machine for myself and learn to fly. The feeling is most delightful and wholly indescribable. The body being supported from above, with no weight or strain on the legs, the feeling is as if gravitation had been annihilated, although the truth of the matter is that one hangs from the machine in a rather awkward and wearying position.

Nor did the Woods let scientific work keep them from participating in the gay life of the American colony in Berlin, along with another young American couple whom they'd met

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and liked after a chance encounter between the two husbands in the physical laboratory at the university. One day Wood noticed a student engaged in a problem similar to his own. After the formal nods and *Guten Tage* of an amiable but defensive neutrality, Wood asked in German for a match. *"Gewiss,"* said the other, and then, "But you're an American, aren't you?" The fellow-student was Augustus Trowbridge of New York, who afterwards rode to fame as professor of physics at Princeton. They brought their wives together, and all four became friends with Charles DeKay, then American consul general. There were rounds of receptions, teas, dinners, grand opera, the Winter Garden with its clowns, including Lavater Lee, who clowned in formal evening dress and without make-up.

Young Wood, aided and abetted by Trowbridge, occasionally did a bit of clowning too—usually at the expense of the stolid German police and petty officials. One of Trowbridge's favorite stories concerning Wood had to do with a fracas on the el. The elevated railroad which girdled Berlin had first-, second-, and third-class carriages. Only princes, millionaires, and fools rode first class. Trowbridge and Wood had green commutation tickets for the second class. One day when the station police were conspicuously on the job and vigilant, Robert bought a yellow third-class ticket, darted through the gate, and, waving it ostentatiously, plunged with Trowbridge into the compartment of a second-class carriage. A policeman was immediately on his heels, entered the compartment, and as the train pulled out began an angry harangue. Wood pretended not to understand German well and by the time they were rolling into the Zoologischer Garten station, the policeman was purple with rage. He seized Wood by the arm and said, "You must get out here."

Wood said reproachfully, in his worst German, "No, I don't get out *here*. I get out at Friedrich-Strasse."

"Dummkopf!" exploded the guard. *"Gleich heraus!"*

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"Nein! Friedrich-Strasse heraus." By that time the train was under way again, and when they got off at Friedrich-Strasse, Wood was arrested. He then produced from his pocket the green commutation ticket and pityingly suggested that the policeman must be either color blind or crazy.

Despite all the high jinks, nonsense, and extracurricular activity, Wood had worked hard and well during the two years in Berlin. His independent researches on determining temperature in vacuum tubes brought his first little early blaze of glory and paved the way for future recognition. His paper had been published internationally.

It was now the spring of 1896. Wood planned to return to America, but was in no hurry about it because he was confident he'd be able to get a post to his liking. Among the friends he had made in Berlin was that strange chap known to the magazine and newspaper editors as Josiah Flynt, to his tramp and hobo cronies as "Cigarette," and to his deploring family as Frank Willard. This talented and celebrated souse —whose fame rested almost as much on his drinking as writing—was none other than the nephew and namesake of Frances Willard, president of the Woman's Christian Temperance Union! Well, here was a summer coming on, with no rush to get back to the States, and this brilliant and friendly if ill-assorted pair of wild geese got it into their heads that they'd like to go for a joy ride—on the new Trans-Siberian Railway, then in process of construction.

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CHAPTER FIVE

Wild-Goose Flight to Siberia—and Return from Studies Abroad to a Job in Wisconsin

YOUNG Frank Willard, better known by tne pen name of Josiah Flynt, under which he had done hobo articles for the *Century* and *Harper's,* had a newspaper commission in the early summer of 1896 to write articles on the Pan-Russian Exposition and Fair at Nizhni Novgorod, and on the Trans-Siberian Railway, then in process of construction. He thought it would be nice if Rob accompanied him. Rob thought so too, but the expense, in terms of transportation alone, if it had to come out of his own pocket would be (as the Scotch say) damnable.

Josiah Francis Temperance Union Willard Flynt had six more drinks, one for each of his names and pseudonyms, and concocted a Machiavellian scheme. For himself, he had already managed to wangle a personal letter from Prince Hilkorff of the Russian Ministry of Railways, giving him limitless first-class transportation and directing all railway officials to favor him in every possible way. His proposal was that Rob become the self-appointed correspondent of an *imaginary* American newspaper and obtain a similar free joy ride over the longest new railroad on earth. Wood's New England conscience couldn't quite be stretched to the point of inventing an imaginary newspaper—but he recalled that he'd once written a

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couple of pieces for the San Francisco *Examiner*. So he closed his eyes while Willard had some handsome cards printed, and salved his conscience by deciding that he actually would do some articles for the *Examiner* and supply copies to the Russian authorities in honest return for the transportation.[1] All necessary passes, documents, and visas were obtained.

And then it turned out that Rob was also to help in a spot of amateur smuggling! It seemed that Willard had previously visited Count Tolstoy, and had promised, at the great man's piteous request, to smuggle in for him a dozen or so of his works which had been published in Berlin but were banned in Russia. Tolstoy had never seen them in type. It was a serious offense, even for a foreigner, to smuggle them in.

The books were duly purchased and hidden in the luggage, and as they approached the Russian frontier, the two conspirators tied the thick, paper-bound volumes beneath their coats, like life preservers, around their chests and middles, with heavy twine. There was an awful moment at the customhouse when police guards in full uniform, with long sabers hanging from their belts, came down the line "frisking" everyone by vigorous slaps. By the grace of God they were fortunately spared this ordeal, possibly on account of the contrast between their more or less respectable appearance and that of the muzhiks, small merchants, gypsies, and other assorted riff-raff who had piled their belongings on the long benches of the customhouse.

On reaching Moscow, they made contact with Chekhov. He was a friend of Willard's but scarcely known outside Russia at that time. They gave Chekhov the contraband volumes for Tolstoy "in the dark of the moon," and he subsequently delivered them via the "underground railway."

[1] He subsequently wrote a long and flattering screed paying tribute to the wonders of the Russian Fair, etc., only to receive from the *Examiner* a printed rejection slip, with the notation that they hadn't returned the manuscript because he'd failed to enclose return postage. This cleared his conscience and ended his career—as an international newspaper correspondent.

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For the rest of their trip, I can't do better than hand Wood the microphone. He tells it well.

Willard had some business with the American Consul in Moscow, and before starting for Siberia we went to see him. We found him in an old dark, dirty office on a second floor, sitting at a roll-top desk over which hung his framed credentials, ornamented with a screaming American eagle and covered with flyspecks. He was apparently Teutonic and could neither speak nor understand English. How he communicated with Washington, if he ever did, was a mystery. Willard had a letter from our Ambassador in Berlin to the Ambassador in St. Petersburg, and hoped for an opportunity to have a word or two with Czar Nicholas. What we got, in deep, guttural disapproval, was:

"Who are *you,* that *you* should ask to see THE—GREAT—WHITE—CZAR!"

It was a purely rhetorical question, and we did not press the point. I spent most of my time lugging my forty pounds of camera, tripod, and dry plates around—occasionally also making water-color sketches, frequently pestered by formidable gendarmes. When they were too suspicious or belligerent, I displayed Prince Hilkorff's letter. We went to St. Petersburg first, and then to Moscow.

From Moscow to Nizhni Novgorod and the Fair was a night's trip. As we had unlimited transportation free, we spent a week shuttling back and forth between the two cities, saving hotel bills by sleeping on the night express, the *Kourierski.* The first-class compartment for two had a single wide seat extending from the window to the wall of the narrow corridor. By raising the back, which was hinged to the wall, and then fastening two bolts, we had an excellent upper and lower berth.

We finally got off for Siberia on the Moscow night express to Chelyabinsk, just beyond the Ural mountains, where the

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then new trans-Siberian line started. We got along well and economically living on trains in Russia. We had our teapots and blankets and were able to buy food at a cost of about half a ruble (twenty-five cents) a day. We lived chiefly on fruit and "meat balls" as we called them—a hash of meat, chicken, and whatnot, enclosed in dough and fried in deep lard. One of them made a meal, and they cost only about five cents apiece, hot from the pot at every railway station. With plenty of fruit, it made a not too badly balanced diet, and we thrived on it. Also, across the tracks, at every railroad station, there was a huge brass samovar, the size of a barrel. At each stop it was charged upon by a crowd of men and women armed with teapots. Hot water was free, and there was always a "free for all" around the samovar. Willard and I formed a "De Land wedge" (football in the nineties), with the help of two or three men we'd met on the train, and went through the crowd like a snowplow through a drift.

At one point in the first stage of the trip, we had an opportunity to leave the train and travel by river for a day or so—on the Volga between Syzran, as I recall it, and Samara. We steamed all day in the bright sunshine, through a flat country, drawing up late at night against a few boards laid on the bank which served as a wharf. It was pitch dark and the single small oil lantern disclosed a pool of ankle-deep, soft mud beyond the makeshift wharf, through which we waded to the road where vehicles awaited us. They were primitive carts or chariots, with wide and shallow wicker baskets half full of straw swung between the high wheels. We piled in with our legs hanging over the edges, and were off at a gallop with shouting and cracking of whips, across the steppes, in total darkness. . . .

At Chelyabinsk we got aboard a trans-Siberian construction train, and had a compartment in a first-class coach which carried construction engineers. The road wasn't yet open for passengers. These trains ran at irregular intervals, perhaps one a week, and made only about twenty miles an hour over rails

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that had been merely spiked to crossties that lay in the sand. The stone ballast hadn't yet been put down. Most of the stations were merely shanties where the telegraph operator lived. The whole job was going to cost over $175,000,000.

Omsk was the first large town we reached. The train was to remain there four days, and we wanted to live aboard her, but the guards and crew (small blame to them) insisted on locking it up for the period. Forced out, we took a room in the Hotel Moscow, where we had to sleep, with our own blankets, on bare mattresses, since sheets and blankets were not supplied. Russian travelers in those days were in the habit of carrying their own bed linen. The mattress was infested with bugs, and our first night was a horror. We brushed the bugs to the floor, but they kept crawling back. Then we put saucers filled with kerosene under the legs of the bed. Then the bugs climbed the wall to the ceiling and began dive bombing us. Next morning we went down to the station, exhibiting our tortured hides—and the letter from Prince Hilkorff—saying we knew His Highness wouldn't want protégés of his to be eaten alive and begging permission to sleep in the locked train. They took pity on us, and we spent a delightful three days in Omsk, walking, riding in the "haycart" cabs, and swimming in the Irtish.

Willard was writing for American newspapers, and in one of the old clippings, this paragraph occurs.

> Except in simplest transactions, the language was a stumbling block. My vocabulary was painfully limited, and Rob could say nothing at all in Russian. When my words gave out, we resorted to pictures which Rob drew with his clever pencil. They spoke with a greater eloquence than words. After he had drawn what we wanted, I would present the sketch to the person with whom we were dealing, and pointing to it, say, "You can?" The man looked sometimes as if he thought we wanted to sell the sketch and were hoping he'd make a bid on it. But as a general thing we were understood, and got what we wanted.

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There were no paved streets in the town and the dust kicked up by the galloping horses and the bouncing wash-basket chariots they drew was terrific. We preferred long drives out over the open fields and prairies. We sang and shouted. We were "American Indians" who knew no better, and nobody cared or stopped us.

A few more days in the creaking, creeping train brought us to Tomsk, where we were sitting at a long table alone in the taproom, drinking vodka, when the door opened suddenly, and looking around we saw a man framed against the darkness of the night. He stared at us for a moment. Then suddenly both he and Willard exclaimed, "Well, I'll be goddamned!" It was an old friend of Willard's, a journalist who'd been doing Siberia from the opposite direction. He'd left Vladivostok many weeks before, coming partly by train, as the road was under construction from both terminals, then by horses. He told us the three hundred miles at the eastern end was finished and in operation. We drank vodka until nearly dawn and staggered up to bed. He was gone when we got up next day.

On the whole Willard and I decided that Siberia was not awfully exciting. What we saw of it was mostly flat as a pancake, with miles of watermelon fields often extending to the horizon. How they ate all those melons, I can't imagine. We used to dig a hole, scoop out the best meat in the center, and throw the carcasses out the window. The train guard caught and stopped us. Section hands were working along the road, and even at only twenty miles an hour, he told us, a big watermelon might knock a man out if it hit him on the head.

The soil seemed good—for raising melons—and land could be bought at fifty cents an acre, but we didn't invest. The truth is we didn't care much for Siberia. We probably hadn't seen enough, but we'd at least seen all we wanted. On the trip back, we found a nice, first-class compartment marked

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"Ladies." Since there were no ladies on the train, we moved into it. The amiable conductor made no objection, but when we reached Omsk an "incident" occurred, in which we (and our letter from Prince Hilkorff) were worsted by some gentlemen of the Russian High Command. As soon as our train had stopped, two soldiers began throwing luggage into our ladies' compartment, regardless of our protests. We began throwing it out of the windows as fast as it came in through the door —and then locked the door. In a few minutes there was a sharp pounding. It was our old friend, the stationmaster who had saved us from being bitten to death by bugs, but now he was accompanied by a miniature army. It consisted of an escort of gendarmes, two petty officers, and two impressive generals in long gray coats with full insignia. The stationmaster said in German,

"This compartment is for ladies, and you gentlemen must *'raus.*"

"But are these generals ladies?" we asked, and refused to vacate.

The captain of gendarmes now stepped forward and said something to us, very politely, in Russian. "What's he say?" we asked the stationmaster. "He says he would regret profoundly the necessity of putting you under arrest."

We produced our magic letter from Prince Hilkorff and the Ministry of Railways. The gendarme captain read it, bowed again, and said something, even more politely than before. The stationmaster again obligingly translated. "He says it's very nice indeed that you have a letter from His Highness—but that you have to *'raus mit.*"

After we were out and the generals, who were no ladies either, installed, the stationmaster flipped over the placard, so that it now read "Reserved." The generals bowed to us, and the stationmaster whispered philosophically, "I am sorry for you—but you see, the Little White Father and Prince Hil-

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korff live far away in St. Petersburg, while those two generals live here in Omsk, and *I have to live here with them.*"

Wood says that he did not see his friend Frank Willard again until some six or seven years later, in America. He was sitting in his laboratory one day, when the telephone rang. His account continues:

"Hello, Bobbie," said a husky voice. "Who's speaking?" I replied. "Frank," said the voice convincingly. "Frank who?" I asked. "Frank," he repeated. "Doan you know ole Frank's voice, ole Frank Willard?" "For the love of Mike," I said, "where are you?" "Here in telephone shentry box, Union Shtation. Say, Bobbie, you got any 'bjection my singin' lil' shong?" "No," I said, "if your door is shut." Then came, in a wailing voice of despair, pitched in a high key, "All I want is fifty million dollash." Pause. Then, "Shay, Bobbie, I got interesting fren' with me—going to bring him up—Joe Dollard, bigges' safe-cracker 'n bank-robber all time. Scotland Yard after him five years. How I get to you?" I gave him directions and hung up as he commenced again, "Shay, Bobbie, you got any 'bjection my singin' . . ."

In about fifteen minutes they arrived. Mr. Dollard did not look like the pictures of bank-robbers in Mr. Hoover's F.B.I. magazine. A man slightly gray, well past middle life, he looked more an old and trusted paying teller in a bank than a bank's safe-opener. Willard had a bottle, and we all had a "lil' drink," as he said, out of three small laboratory beaker glasses. We talked awhile of old times, Mr. Dollard listening respectfully but slightly bored, and then, having business elsewhere, he excused himself in a very dignified manner and departed.

Frank told me that he had come to Baltimore at the request of Mr. Leonor F. Loree, then president of the Baltimore and Ohio Railroad. Mr. Loree wanted to employ him, disguised

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as a tramp, to test the efficiency and loyalty of his railroad detectives; he was to be the house guest of Mr. Loree, but had been on a jag for ten days, and could we take him in for the night as he was broke—while he sobered up for his visit? He talked quite normally, if permitted to sing the opening bar of his "lil' song" at intervals. This seemed to relieve the strain of pretending sobriety, as a slight cough will relieve a long-endured tickling of the throat in a theater. So I took him along in my car to the house. Gertrude was out. Frank had evidently slept in his clothes and was apparently wearing the perspiration that he was born with, as Gertrude once said of a Spanish lady in Mexico who was entertaining her at tea. So I filled the bathtub full of hot water, and suggested a nice warm soak before dinner. Hearing nothing from him for half an hour, I tried the door, which opened disclosing Bacchus asleep in the tub. I woke him by turning on the cold water.

In the course of half an hour he appeared spick and span and in excellent humor. He began by reciting some of his recent adventures and showed not the slightest sign of his spree. We listened entranced, for he was a brilliant talker. Finally he slumped slightly in his chair and turning to Gertrude said, with a rather silly smile, "Mrs. Wood, would you have 'n' objection to my singin' a lil' song?" "Why, no, Mr. Willard, I'd be delighted to have you." Then he really relaxed and his voice came out strong and clear like that of a drunken sailor: "All—I—wan'—is—fifty—million—dollash!" He paused, blinked once or twice, and resumed the conversation where he had left off, as if nothing had occurred.

Gertrude had telephoned for a thick steak and a bottle of Major Grey's Indian chutney, and dinner was announced. There was a large dish of Hamburg black grapes between the candles on the table, and Willard, refusing all other nourishment, ate them slowly one by one as he talked, until, like the Walrus and Carpenter with the Looking-Glass oysters, he'd eaten every one. After dinner we listened enthralled to

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the story of his travels in Afghanistan, where he walked over the celebrated Khyber Pass into India. It was two o'clock before we even thought of bed. He passed out of our hands the next day and we never saw him again.

His end was very tragic. He contracted pneumonia in Chicago, locked himself up in a room in a cheap hotel, with a few bottles of self-prescribed "medicine," and only shouted "No—keep out," when the maid knocked at the door. He had been dead twenty-four hours when the door was unlocked from the outside.

In the autumn of 1896, the Woods returned to America with their two children growing out of babyhood and the German *Kinderfrau* whom they couldn't bear to leave behind. They spent the winter at his mother's house in Jamaica Plain, while Robert continued his independent research in the laboratories at M. I. T. Professor Charles Cross of the Physics Department had extended this courtesy and given him a laboratory. There he continued his work on vacuum-tube discharges. By the next spring (1897) successful negotiations were under way for an instructorship at the University of Wisconsin.

The Wood family spent the summer at Cataumet, Massachusetts, on Buzzards Bay. Wood's cousin, Bradley Davis, was working at the Marine Biological Laboratory at Woods Hole, within bicycling distance, and some old friends owned a summer cottage there. Wood says he was taken on as outboard ballast by the owners of one of the small racing boats that took part in all the Corinthian yacht club races; he hugely enjoyed the jockeying for a start, which was a new experience for him, though he had sailed a small boat all his life. While in bathing one day he happened to invert a wooden pail over his head, and holding it down on his shoulders with his hands and kicking with his feet, amused the children by the sight of an animated pail moving along by itself. Next day he cut a rectangular hole in one side, set a piece of plate glass in it

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STUDENT IN BERLIN: Wood in the private laboratory he rigged up in the attic of the University of Berlin laboratory.

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LILIENTHAL'S LAST FLIGHT: A photograph made by Wood in 1896 of the last successful flight of Otto Lilienthal, Germany's great pioneer glider. On his next attempt the following day—Wood was invited to attend but couldn't—Lilienthal was killed.

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for a window, and put forty pounds of lead boat ballast around the rim. This weight held the bucket down over the head when filled with air and submerged in water, and enabled the wearer to sink comfortably to the bottom. Then, antedating Beebe, they connected the bucket to a bicycle pump (operated on a rowboat) with twenty feet of rubber tubing, and stayed under water as long as they liked, viewing the fish, seaweed, and submarine landscape.

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CHAPTER SIX

Wood as Campus Wizard, Thawer of Pipes, Driver of Steam Wagons, Roman Senator

When Robert Wood obtained in 1897 the academically humble and poorly paid post of junior instructor in physics at the University of Wisconsin, in Madison, he was a young man just turning his twenty-ninth year, married, with two children—a third, Elizabeth, soon to be born—and he was completely ignorant of the highly special branch of physics destined to bring him his later greatest glory. But while he knew next to nothing yet of physical optics, he was already a daring experimenter in the general field, and began almost immediately to revolutionize undergraduate classroom technique at Madison.

It all began gaily with a series of lecture circuses, staged for the edification and joy of the students, climaxing soon in mirages and tornadoes. The idea that he, as well as Nature's God, could create these phenomena had come to him the previous summer in San Francisco, when he'd noticed one day a beautiful mirage on the city sidewalk at the top of a hill, where one could look along a long stretch of sun-heated pavement with a sky background behind it. The pavement appeared to be flooded with water in which the inverted reflection of pedestrians was clearly visible. Wood had stationed his two small children at the end of the pavement and photo-

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graphed the result. Today this type of mirage is observed constantly by motorists on pavements or streets, but at that time it had only been reported as occurring on wide expanses of hot sand in the desert. To create his miniature phantasmic oases and actual whirling sandstorms he procured four flat sheets of iron, each about four feet long and eight inches wide. These he laid end to end, supported on iron stands, making a long, narrow, level vista, which he sprinkled thickly with sand. At the further end he mounted a mirror which, when viewed from the opposite end, showed the reflected image of the sky-backed window. A row of miniature mountains and some palm trees, cut out of paper and arranged on the sand in front of the mirror, represented the horizon of his desert landscape, which was warmed from below by a row of small gas burners under the iron plates instead of from above by the sun. Would it work on this small scale? He lit the burners and commenced observations. The mountains and palm trees were clearly silhouetted against the bright sky, but presently a small pool of brilliantly shining water appeared in front of them at the base of the mountains. If the eyes were raised an inch or two above the level of the sand, the lake vanished, only to reappear as soon as the viewpoint was depressed, just as does a real mirage if we ascend a small hillock. And now the pool increased in size and the reflected images of the mountains appeared, and "if the eye was lowered a trifle more, the mountain chain disappeared completely in the illusory lake, which had now become an inundation." Needless to state, the students were enchanted—almost to the point of howling with joy—and from then on the new "prof" was ace-high.

Wood next regaled them with his tornadoes. The atmospheric conditions (a layer of hot air close to the ground, with cooler air above) which exist with mirages also give rise to the "dust whirls" so often seen on American deserts and, on a larger scale, to tornadoes. One of the metal plates (cleared of sand) was sprinkled with precipitated silica powder and

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heated by a few burners. In a few minutes beautiful little whirlwinds began to run about over the surface, spinning the light powder up in funnel-shaped vortices, which lasted sometimes ten or fifteen seconds. By sprinkling a large square plate of sheet iron with sal ammoniac and heating it strongly by Bunsen burners, white fumes were given off, and presently, at the center of the plate, there mounted to a height of six or eight feet a most perfect miniature tornado of white smoke!

A little later in the year he invented a new form of pseudoscope. When viewed through this instrument, an old-fashioned washbowl appeared as a white dome, and when a marble was dropped into it, it seemed to roll up and down over the surface of the dome in defiance of the law of gravitation, finally stopping on the summit!

Another memorable lecture-room stunt was his demonstration of the curved flight of baseballs as pitched by the then Dizzy Deans—leading on to the parabolic orbits of planets and comets as pitched by the Lord God Almighty. The limited space in the lecture room had raised difficulties. If the curve was to be made at all apparent in that limited space, the ball would have to be exceedingly light and the axial rotation very rapid. Wood found the ordinary oak ball or oak apple suitable for this purpose. A ping-pong ball might have been even better. A strip of rubber band six or eight inches long and one-eighth inch wide was wound under tension around the ball, two or three turns being enough, and the ball catapulted forward by means of the remainder of the band. A total deflection of forty-five degrees was easily obtained, and when pitching the "rise" (in which case the free part of the band is below) the ball, starting in horizontal flight, would often ascend half way to the ceiling. Try it for yourself, if you don't believe it.

An experiment followed showing in miniature the elliptical and parabolic orbits of the planets and comets around the sun. The conical pole piece of a vertical electro-magnet was covered

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with a large sheet of plate glass, and a steel bicycle ball projected toward a point a little to one side of the magnet, which represented the sun. The ball whirled around in a beautiful ellipse with the sun at one focus, as Wood demonstrated with a glass plate covered with a thin film of soot, obtained by holding it over a smoking flame. In this case the ball left a record of its path on the film.

The publication of a scientific paper on this experiment led Wood into his first brief polemic. An older professor of physics in one of London's universities criticized the paper in a letter to the London *Nature,* saying that the experiment did not illustrate Newtonian orbits, as the magnetic attraction varied as the inverse fifth power and not as the inverse square as in the case of gravitation. This was young Wood's first slap—but he sat down and drew a diagram of his experiment with the lines of magnetic force put down and realized at once that the ball was not coming in along the lines of force, but was cutting across them at an angle, and that it was the horizontal component only that governed the orbit. He set one of his young students to measure the effective force in the plane of the glass plate, and it turned out to be very nearly proportional to the inverse square. In the meantime, letters of criticism had appeared in several other English technical journals, and Wood joyfully sent off a rejoinder giving the results of the actual measurements.

These must have been great days for the students at Madison, while Wood's introduction of excitement, dramatics, and circus technique was beginning to attract world-wide attention both to him and the university. He had been from earliest childhood, and still is today, a circus man, a showman—just as were Archimedes, Galileo, and Copernicus. He is full of childish vanity, God knows, and dearly loves the limelight and applause—but the excitement is more in the thing shown than in himself, so that while he sometimes seems to be an egotist and exhibitionist, he is not actually one in the unpleas-

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ant connotation of the words. This distinction was keenly sensed by Professor Benjamin Snow, then head of the Department of Physics at Madison. A new young instructor, or assistant professor as he presently became, was and still is small potatoes in any major university, and if Wood had not been encouraged by this important ally higher up in the faculty—if there'd been an academic stuffed shirt at the head of the department—he could scarcely have obtained the necessary cooperation. Luckily, Snow himself was a dynamic, enthusiastic lecturer and fond of spectacular stunts. The fun Snow and his young instructor had together is recorded in Wood's notes.

He made me his assistant in the course on general physics for the sophomores. My duties at first were those of the uniformed darky who passes things to the conjurer as required. He was never satisfied with any piece of apparatus that was not the largest in the world, and I made a hit at once by constructing an enormous box for making smoke rings a foot in diameter, similar to the one I had made for my lecture in Chicago, when I was a student in chemistry. A dynamic smoke ring that would knock a large pasteboard box at the further end of the lecture table onto the floor delighted him beyond measure. It was also a new idea to him that smoke was not necessary for the formation of the ring, at all events it had never occurred to him that an invisible ring of air knocking things about was the more spectacular demonstration. Interested for the moment in these whirling vortices, I fussed around and concocted a number of new experiments with the rings, which were described and illustrated with photographs again, this time in the London *Nature,* including a method of making a ring one half pure air and the other half charged with smoke, so that it left the tube from which it was blown in the form of a U.

This can be done with a pasteboard mailing tube an inch or so in diameter by blowing dense smoke very gently along

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the bottom of the tube, held horizontally, so that the smoke flows along the bottom of the tube to the other end; then a gentle puff is given, and the half ring emerges. Another device made it possible to form a fat air ring, like a doughnut, with a white thread of smoke as a core, spinning with terrific velocity. This illustrated the very high velocity of rotation along the core of the vortex ring, or on the axis of a tornado. Illustrating the difference between *force* and *work,* the latter being defined as a force moving against a resistance through a finite distance, Snow was in the habit of leaning against the end of the lecture table and pushing against it with all his might. "I push, and I *push,* and I PUSH!" . . . Getting red in the face, perspiration breaking out on his brow . . . "There is no motion, I push and push, and I don't do a particle of work!" . . . almost collapsing from his herculean efforts.

In one of his lectures I caught him in a slight mistake and being unfamiliar with the rule that "little assistants should be seen but not heard" called his attention to it at the close of the lecture.

His subject was gravitation, and he reminded the class of Jules Verne's story of a journey to the moon, saying that the author never made a mistake or violated any laws of physics in his fiction.

"You will remember," he said, "that when the projectile crossed the center of gravity between the earth and the moon, the passengers inside weighed nothing, but floated about without any support, and that, gentlemen, is just what would happen."

At the end of the lecture, while some of the students were hanging around asking questions and inspecting the apparatus, I ventured the remark that in that particular case Jules Verne had certainly made a mistake; the passengers would float about as soon as the projectile was out of the earth's atmosphere, for gravitational effects are not felt inside a freely falling or freely rising container. "I think we can prove it by experi-

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ment, by putting a half dollar on this book and tossing it up before the window. I think that daylight will be visible between the coin and book throughout its flight," which was exactly what happened after two or three trials. This convinced Snow that Jules Verne was wrong, in this instance at least.

All these classroom discoveries and demonstrations were of interest, perhaps, only to students and scientists—but our young instructor soon followed them up with a "practical" invention which immediately obtained for the university a gift from the state of $200,000 and saves the world each winter millions of dollars in losses by fires resulting from the crude methods employed by plumbers. It was the now universally known Electric Thaw.

Since my own knowledge of what to do when my pipes freeze underground is confined to a number in the Rhinebeck Village telephone book which brings "Cart" Sipperley humming out with a service wagon full of precisely the gadgets Wood adapted forty years ago in Madison, and since all I understand about those coiled, imposing gadgets is that they unfreeze my pipes without the need of tearing up my floors and driveways, I've persuaded our Promethean Wood to dictate his own version of how he invented the Electric Thaw, and how it does the thawing. "You can brag a little, if you want to," I told him, and he said with a hurt expression, "You know I *never* brag."

The unprecedented cold (he dictated) throughout the whole Northwest in the winter of 1899 froze the ground in Madison down to a depth of eight feet and more. Half the service pipes in Madison were frozen and there was some fear that the mains had ceased functioning. Bonfires were burning on various premises where the plumbers were digging down to get

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at the service pipes. Our own pipe was frozen, and we had paid a local plumber twenty dollars for thawing it.

I was walking down Langdon Street to the laboratory one morning and passed a group of plumbers who were pushing into the frozen pipe a rubber tube attached to the spout of a portable boiler in an effort to thaw the pipe with steam. They were having trouble because they couldn't make the tube turn a corner.

I continued on my way to the laboratory, thinking the situation over, and it came into my mind that a heavy current of electricity passed through a metal conductor raises the temperature of the metal, and that moreover an electric current would follow the conductor around any number of turns. Could not this be the solution of the whole trouble—by merely joining the faucet in the house to one wire of an electric generator and carrying the other wire to a faucet in a neighboring house?

On reaching the laboratory I went at once to the office of Professor Jackson, the head of the Department of Electrical Engineering, and suggested this plan to him. He objected to it on the ground that the current would be carried by the earth rather than by the pipes. But when I pointed out that the ground was frozen and that ice was a nonconductor, he agreed to join me in making the experiment.

That same afternoon we had the electric light company bring a transformer on a wagon to the home of Senator Vilas, Chairman of the Board of Regents of the university. Plumbers had been at work for a week in and around his house trying to find a three-hundred-foot service pipe which joined the house with the street main, no record of its position being available. The lawn was covered with what looked like numerous newly made graves and fires burning at other spots to soften the ground.

The linesman who came with the wagon climbed a pole and brought down wire leads from the overhead line supplying the electric light. These were attached to the secondary

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coil of the transformer, while the wires from the primary were joined to the faucet in the cellar and the street hydrant three hundred feet distant respectively. A large tub of salt water with two copper plates was placed in the circuit to govern the strength of the current.

The current was turned on, and we waited at the open faucet in the cellar. At the end of ten minutes, we heard a gurgling sound and presently a jet of muddy water mixed with ice and rust particles spurted from the faucet into the sink. Loud cheers from the Senator's family greeted this eruption, and a few minutes later, the butler appeared with champagne glasses, et cetera.

The Madison *Democrat* the next morning contained a two-column article describing this successful solution of the water famine, and it was relayed by the Associated Press all over the country.

Ever since that time, the electric method has been the standard method over the whole world—one of the large scale developments in recent years being the thawing of a twelve-inch main under the Hudson River, frozen at the two ends where the pipes came near the surface of the ground.

This discovery came at an opportune time for the university. The state legislature was then in session, and President Adams had asked for an appropriation of two hundred thousand dollars to build an engineering laboratory. Serious opposition had been offered by the legislators, who asked what the university had ever done for the state. This was satisfactorily answered by referring to the recent gift to the people of the thawing invention and the method of relieving recurrent water famines. Thereupon the legislature promptly and enthusiastically granted the request.

The trustees of the university rewarded this gift to the people by changing my title from that of instructor to assistant professor.

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The reader will agree, I think, that in this case the professor could have bragged a little if he felt like it. My own guess is that in addition to the inventive genius involved, he showed the cagey practical wisdom of the fox in choosing the Senator's pipes for the initial demonstration! Maybe he knew and maybe he didn't that Senator Vilas was a key man on that appropriation committee. As for the plumbers of the world, instead of being disgruntled, as some newspapers had predicted, they were enchanted. They all now use the Electric Thaw, the wide world over.

Young Wood's next extracurricular contribution to excitement and revolution on and outside the campus involved no inventive genius. In the autumn of 1899 he brought out as a bright new toy from Boston an early model of the Stanley Steamer—the first automobile ever seen in the state of Wisconsin. And he soon set the state on its ear by scorching around at the terrific speed of twenty miles an hour. It arrived just before Thanksgiving Day, and one of the first things Rob did was to invite President Adams, the venerable, white-bearded head of the university, for a joy ride.

"I took him out," says Wood, still chuckling after these long forty years, "to the Thanksgiving football game. The field was surrounded by a dirt track where horse races were held. We careened furiously around the track, with the brass band blaring, students cheering, and old President Adams's white hair and beard flying in the wind."

And then—believe it or not—Wood and Professor Joseph Jastrow drove all the way to Milwaukee! It was eighty miles through ruts and sand and dirt, and the gasket of the steam chest blew out. Wood cut out a new one from the rubber tread on the car's step. They got there and came back—literally under their own steam. This, of course, was front-page stuff. The Madison *Democrat* carried the news that "two scientists" had "demonstrated the practicability of automobiles for

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ordinary country roads," and that "there was scarcely any inconvenience or danger from the frightening of horses and pedestrians along the way."

However, the column entitled "Vox Populi" in that same journal raised an almost immediate yowl of protest. Wood and his Stanley Steamer were making a hell of a sensation. It was one of the first good cars ever made—but it *was* a steam engine. It made the noises and emitted the smoke and steam and occasional flames peculiar to steam engines and Chinese dragons. Also frequent loud explosions when the fuel was turned on, vaporized in hot tubes, and passed to the burners, which were ignited at the side with a match. Whenever there was a transverse wind of considerable force, sheets of blue fire were blown out at the side of the car, and small boys shouted, "Hey, Mister, your thing's on fire!" But what was worse for timorous souls who never dreamed of owning one was that this hell buggy whizzed over the roughest roads at "a dangerous and appalling speed." So Rob was openly denounced as a "scorcher," in a letter to the editors by a dear old lady who signed herself "Carroll Street." She wrote:

I may be over-nervous in my advancing years, and magnify unduly modern dangers; but I do dread our fast bicycle riders, and now that we have an automobile I hope I shall be excused for experiencing some dread of that too. It is not on my own account, however, that I entertain fear, but for my grandchildren whose thoughtless play often takes them into the street. The automobile goes like a "scorcher"—at 20 miles an hour I should judge—too fast certainly for public safety on our thronged streets. Scorching is under ban. Now I suggest that an ordinance be passed forbidding automobiles to exceed a 6-mile speed within the city limits. There will be more of these machines among us soon, I have no doubt, and the question of regulation should be settled at once. Such action, I am told, has been taken in all other places where automobiles are run. The new vehicle gives tone to the town, and I am not too old to like that. I even want to see others come, but let's have the ordinance before any damage is done.

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After Dr. Wood had found this letter, buried in his jumble of old yellow clippings, I said, "Well, I guess—except of course for your serious scientific work begun at Madison, which we haven't touched yet—this about cleans up the high lights of the Wisconsin period."

He said, "Yes . . . but I've forgotten to tell you I'm now a senator out there. . . ."

"What kind of a senator?"

"I'm a Roman senator, toga, gold band, and everything. . . ."

"How come?"

"Well," said he, "it happened years later, after I'd gone to Johns Hopkins and bought this place here at East Hampton. You know Albert Herter has had a studio and summer house here for years. He came over one day and asked if I'd pose for him. I told him it depended on what kind of a pose. He told me it was for a mural in the Statehouse at Madison, Wisconsin, and that he wanted me to be a Roman senator. So I posed in a toga with a gold band around my head. The likeness was perfect even to the lock of black hair that formerly hung down over one side of my forehead, a strange coiffure for a Roman senator. I later saw the mural, covering one whole wall of the Appellate Court. The senators are seated in a semicircle, with me at the end in front receiving the Roman general, with his aides, carrying the spoils of war. One of the present members of the Department of Physics told me they always took visiting physicists to see it as a 'horrible example' of what happened to brash young instructors."

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CHAPTER SEVEN

Wood Begins His Great Work with the Spectroscope—Becomes Grandfather to Mickey Mouse—and Lectures Before the Royal Society

YOUNG Professor Wood's early and final decision to make physical optics his special field came in a curious way, toward the end of his first year at Madison. Professor Snow had asked him to undertake a graduate course of lectures on that subject—which Wood had never studied before. He willingly agreed and began to bone up, keeping just a jump ahead of his classes at first. He says that when the bell rang at the end of the hour he had just about reached the end of his knowledge of the subject. But soon he began pulling ahead. He was reading the current journals of physics and found that marvelous new fields of optics were being opened up which were not treated in the textbook he was using, Thomas Preston's *Theory of Light.* By the end of the year he had done enough independent study to realize that Preston was at least ten years behind the times. So he made his decision—he would make physical optics his specialty, and he would write his own textbook!

You will have to go a long way to beat that, I think, as a piece of sheer scholastic impudence. But the joker is that he did it—and that the monumental opus stands today, in its third revised edition and translated into German, French, Russian, and other languages, as one of the world's standard

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books on the subject. The book was to take five years to complete, and was not to appear until Wood had gone to Johns Hopkins, but he immediately plunged into experimental work that was to get him world-wide attention and, in the local papers, the name of the Wisconsin Wizard.

Just what was the subject that Robert Wood was choosing? Physical optics is the scientist's name for what he practices when he combines the resources of physics and chemistry to study and learn all he can of the nature, habits, and possible uses of light. In a sense it is a science that is as old as man's first speculation of the cause of the rainbow; but as a modern science it may be said to date from Sir Isaac Newton, who first proved that a prism simply breaks white light into its component parts, which can be reassembled again into white light. For nearly two hundred years after Newton, scientists were preoccupied with the basic characteristics of ordinary light. They measured its velocity through space. They noted how light rays were bent when they passed through other media, such as glass, quartz, water, or colored solutions, and they formulated the laws of this bending, or *refraction,* to give us the telescope and the microscope. They noted how light passed through a narrow slit tends to spread out, and how no shadow, when minutely examined, shows a sharp break between black and white, and they named this phenomenon *diffraction.* They studied also the phenomenon of *interference,* in which one ray of light cancels out another and complete darkness results. By the middle of the nineteenth century they knew enough about light to know that light, heat, electricity, and magnetism were allied phenomena: they were waves of energy radiating in a hypothetical medium called the ether, and they differed from one another only in their wave lengths and their frequency of vibration.

The classical theory of light had thus been rounded out long before Wood came on the scene. But vast new possibilities in physical optics had been opened up in 1859 when the

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spectroscope came into use for detecting the chemical nature of substances. A spectroscope is nothing more than a prism mounted between a source of light and an adjustable eyepiece (or photographic plate) for accurate observation. The prism bends each color of light that enters it at a different angle; it is the spreading out (the scientist calls it *dispersion*) of the component parts of white light that gives you the rainbow or solar *spectrum* you see in a crystal chandelier or in a spectroscope when sunlight is passed through it. But Bunsen and Kirchhoff in 1859 discovered that if, instead of passing sunlight through a spectroscope, you used the light of chemical substances heated to luminosity, you got spectra of an entirely different kind, *and that the substance could be identified by its characteristic spectrum* (Wood had identified the origin of the boarding-house hash by just this method).

This discovery made the spectroscope one of the major instruments of modern science, and opened almost illimitable fields for physical optics. For light became not only something to be examined in itself, but a powerful tool for examining the nature of the physical world. The minutest traces of substances revealed themselves in their spectra; and the most distant nebulae and stars showed their composition—and even their velocity and direction—in their spectra. The subject became more complicated as it developed, for it was found that the same substance gave different spectra depending on the physical state in which it was. Thus the analysis of spectra revealed not only the chemical composition of substances, but the physical condition in which they existed as well. And different types of spectra were investigated: the *emission spectra* of luminous bodies, and the *absorption spectra* emitted when light of various kinds is passed through nonluminous liquids and gases. With all this development, the task of the scientist in physical optics became that of subjecting light to every conceivable kind of test to make it tell more of its nature and the nature of its source. He studied the emis-

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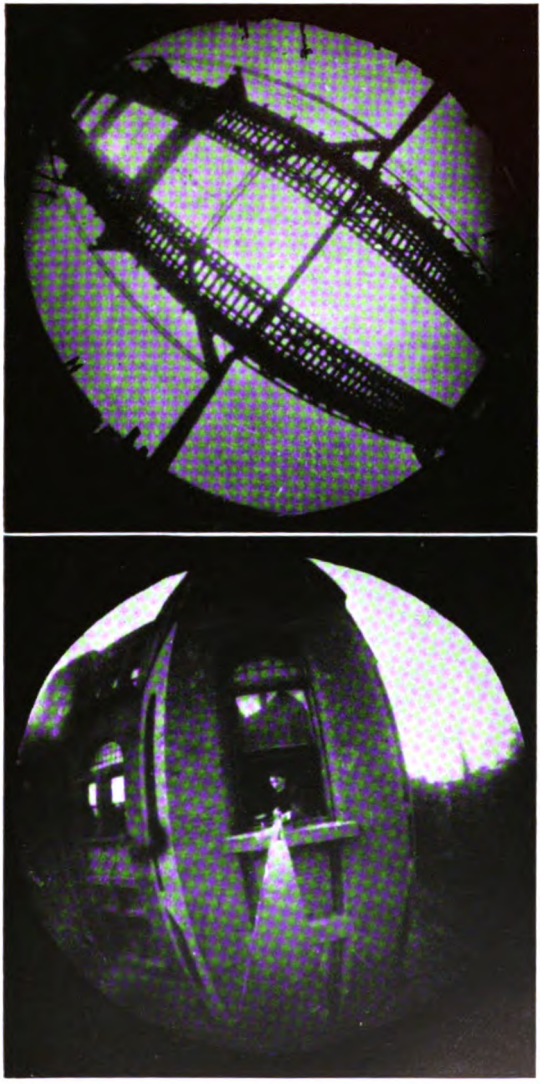

FISH-EYE VIEWS: Photographs Wood made with his "fish-eye" camera (see page 128). *Top:* the first outdoor photograph taken—a railroad trestle seen from directly underneath. *Bottom:* a photograph Wood took of himself in the window of his laboratory, by putting his camera at the end of a six-foot plank and working the shutter by remote control.

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MORE FISH-EYE VIEWS. *Top:* the camera is on the ground and a group of men stand in a circle around it. A group of fishermen standing around a small trout pool would look something like this to the trout looking *upward* from the bottom of the pool. *Bottom:* a photograph of McCoy Hall at Johns Hopkins, taken from across the street.

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sion of light by luminous bodies under various types of excitation, such as sparks, electric arcs, and gases at low pressure in vacuum tubes carrying an electric current. He examined *fluorescence,* or the emission by certain substances of light of a different color from that of the light played upon them. He placed the source of light in powerful electric and magnetic fields. And he carried his investigations beyond the bounds of visible light to the region of the infrared and the ultraviolet and X rays.

When Wood came on the scene at the end of the nineteenth century, physical optics was in this exciting stage of evolution. And physics in general was in one of its greatest transitional stages—the stage between the atom and Newtonian physics and the electron and Einstein. Wood's role was to be the daring experimentalist whose work would continually challenge the formulations of the theoretical and mathematical physicists, and thus bring them closer to the ultimate truth. And equally important, his experimental demonstrations would confirm the truth of many of their purely theoretical conclusions. His first major contribution to physical optics is a beautiful example of this—and also an example of the amazing scope of his special field of science. Here is his account.

It was the total eclipse of the sun on May 28, 1900, that started me on research problems, the solution of which might be considered as contributing to knowledge in the field of physical optics. What had gone on before was for the most part along the line of demonstrations and interpretations. The Naval Observatory at Washington had invited me to become a member of its eclipse expedition and I was stationed with the group "on location" at Pinehurst, North Carolina, near the center of the belt of totality where the duration of the total phase was at its maximum. Here I had my first view of the solar corona and the red hydrogen flames blazing up at various points on the rim of the sun. The "flash" spectrum was of

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especial interest to me. Just before totality, when the edge of the sun is about to disappear behind the moon, one sees for a second or two a thin crescent of fire, which, if viewed through a diffraction grating or prism, is spread out into a spectrum of colored crescents, of all the colors of the spectrum, separated by dark intervals of various widths. This is the so-called chromospheric or "flash" spectrum, the chromosphere being the atmosphere of luminous metallic vapors that surround the sun. It is the absorption by this atmosphere of glowing vapor of the far brighter light of the incandescent fluid surface of the sun that produces the dark lines in the sun's spectrum shown by the spectroscope. These lines are not absolutely black but contain the less brilliant light of the luminous vapor.

On my return to Madison in the autumn I read in the October number of the *Astrophysical Journal* an article by W. H. Julius, the Dutch astronomer, advancing the bold theory that the "flash" spectrum was due to anomalous dispersion of the white light originating at the fluid surface of the sun. I immediately started work to see if the "flash" spectrum could be produced in the laboratory. Before Christmas I had sent off to the *Astrophysical Journal* an account of a successful experimental verification of the theory of Julius. To accomplish this it would be necessary to form on a white surface an atmosphere of sodium vapor in which the density changed very rapidly as the surface was approached. This I accomplished by heating metallic sodium in an iron spoon just below the under surface of a slab of plaster of Paris, expecting that condensation of the vapor on the cold surface would produce the required change of density. The white surface on the further side of the sodium atmosphere was illuminated by an intense beam of sunlight concentrated by a large lens. This represented the white hot surface of the sun, while the sodium atmosphere represented the chromosphere. Viewing the white spot with a telescope and direct vision prism, and moving the instrument upward, thus causing the spot to become fore-

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shortened into a line, the sun's dark absorption lines appeared, just as they do in the case of an eclipse, when the sun's disk is nearly covered by the moon. On moving the spectroscope until it was just inside of the plane of the illuminated surface, the solar spectrum vanished, and there suddenly blazed out two narrow yellow lines in the place occupied by the dark absorption lines of the continuous spectrum which had just vanished. Julius wrote me immediately of his delight at the outcome of this experiment, which furnished strong support for his theory. As a result of the successful outcome of this experiment I realized that a study of the optical properties of the dense absorbing vapor of metallic sodium would probably yield results of importance for the confirmation of current optical theories, and I decided to commence with a study of the dispersion of the vapor.

Here you have a beautiful example of the magnificent range of Wood's field of physics. A man reproduces in the laboratory a model of something that is taking place ninety-two million miles away, and contributes to our knowledge of the nature of our prime source of light. The experiment is interesting in another way, for it shows an abiding characteristic of Wood's experimental technique—his use of the simplest kind of equipment in the most daring way. You will see a lot more of this in the rest of the book: old iron pipes, abandoned bicycle parts, household bric-a-brac—all these play their parts in some of Wood's most important work. The man has a genius for using the instrument closest to hand for his own purposes.

Wood's work on sodium vapor and its optical properties, which began with this experiment, was to continue through most of his career. Maybe it was the small boy in Wood that made him attach himself to this substance, which has the unusual property of exploding violently when it comes in contact with water. At any rate, he set himself the task of mak-

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ing it yield all its secrets. In doing so he made basic contributions to our modern theories of the nature of all matter.

With sodium vapor, and also with iodine and mercury vapor, Wood was soon getting hitherto unknown types of spectra. His results gave the theoretical physicists immediate sharp pain and anguish. Without having asked their permission, this troublesome young experimenter had increased the number of spectrum lines in the principal series of sodium from the eight previously known to forty-eight, and had found a band of continuous absorption in the ultraviolet region. On the theory current at the close of the nineteenth century, each spectrum line was supposed to be emitted by a separate "vibrator" in the atom; or, as Darrow expressed it, an atom was regarded as being analogous to a clarion of bells. Rowland himself once said that the iron atom must be regarded as more complicated than a grand piano. Wood's results made a further complication, and it was not until Niels Bohr in 1913 formulated our present theory of the nature of the atom that Wood's results could be explained; and in Bohr's first paper on the subject he cited Wood's work on sodium as the most perfect confirmation of his theory of atomic radiation.

It was in Madison that Wood started another line of special interest in his field that was to stick with him for life. He became interested in the construction and uses of diffraction gratings. These are plates of glass or metal upon which have been ruled a large number of fine lines (sometimes as many as thirty thousand to the inch). Diffraction gratings perform the same function as prisms, dispersing light into its components, and for many kinds of spectroscopic work are greatly superior to prisms. Naturally their construction is a delicate task. The great Rowland made the finest gratings of his time in his laboratory at Johns Hopkins, and Wood was later to carry on and improve Rowland's process at that institution. And as I write this he is getting ready to go to California with his *chef d'œuvre!*

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Wood's work with diffraction gratings had one immediate by-product that gave him wide attention while he was still in Madison—the invention of a new process of color photography which no one had previously dreamed of. It came about in a curious way. Wood had been invited by Professor Snow to a meeting of the Town and Gown Club, a select group of local potentates and faculty members which met once a month and listened patiently to an hour's dull lecture. Membership was considered the highest honor in Madison, and it was deemed a distinction even to be invited as a guest. Apparently Wood was insensible to this honor, and smoked throughout the lecture and thought his own thoughts.

On the way home, as he and Snow were tramping through the deep snow, Wood suddenly said: "I've worked out all the details of a radically new process of color photography. If you take a diffraction grating, put it in front of a lens before a light, and put your eye in the green of the spectrum, the whole surface appears green. If another grating with a coarser spacing is put beside it, this grating will shine with a red light." And all the way home through the snowstorm Wood proceeded to describe in detail the whole process, which he had thought out completely during the Town and Gown lecture.

In the spring of 1899 Wood conceived the idea of studying light waves through their analogy with sound waves—and of projecting drawings of the latter on a cinematographic screen. There were, properly speaking, no motion pictures in those days, but the primitive machine had already been invented, and Wood was the first to foresee its possibilities in connection with animated drawings.[1]

[1] Wood is frequently introduced to laymen by his scientific colleagues as "the grandfather of Mickey Mouse," and a curious thing happened only last year (1940) in connection with Mickey Mouse's Woodian ancestry. The AP carried a story that a professor at Wellesley had "applied the art and technique of Walt Disney" to the projection of animated mathematical drawings and curves. Mickey Mouse technique had completed the circle—beginning as a scientific abstract, and returning via Disney's famous comics to its source.

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He had been puzzling over what form the light wave must assume in some of the complicated processes of reflection, as, for example, in a hollow spherical mirror. It occurred to him that this question might be solved by making use of the analogy between sound and light. A German physicist named Toepler had devised an instrument by which it was possible to photograph the spherical sound wave given off by the "snap" of an electric spark. This wave is, in fact, a spherical shell of highly compressed air, which expands with velocity of more than a thousand feet per second. To catch it before it has passed out of the field of the camera, it must be illuminated by the light of a second spark which occurs at about one ten-thousandth of a second later. With Toepler's instrument, he made a long series of photographs of sound waves undergoing reflection and refraction, as well as diffraction and dispersion. One of the photographs showed the reflection of a sound wave from a little flight of steps made of glass and placed beneath the spark. The echo from the flight of steps consisted of a train of waves and constituted a musical note of high pitch. This phenomenon, the conversion of an explosive sound into a musical note, can be verified by clapping the hands together in front of a flight of steps, if one is in the open air where no echoes from the walls or ceiling interfere with the observation of the musical note which is echoed back from the steps.

The reflection of these waves from curved surfaces was extremely complicated. He first worked out a geometrical method of constructing their forms from theory, as they went through their contortions. These evolutions he drew on paper in black ink, by the hundreds, and then photographed them one at a time in succession on motion-picture film, which had only just been put on the market. Next he obtained a machine for projection, and found that the method gave admirable results. The black line representing the sound wave moved along, twisting and folding back upon itself in curious ways,

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and gave a striking picture of what was actually also happening to light waves in the case of reflection of light under similar conditions. Practically all of the optical phenomena of reflection and refraction of light were reproduced by sound waves and could now be studied in a new way.

The results were communicated to scientific journals here and abroad. Also the daily newspapers, caring nothing about the analogy with light waves—which was the only thing Wood *did* care about—were excited by the novelty of "seeing" sound waves, and reproduced page after page of the photographed drawings.

In January, 1900, Wood received an invitation from the Royal Society of Arts asking him to come to London and deliver a lecture on his color photography at the February meeting. Then came a letter from the physicist, Sir Charles Vernon Boys, inviting him to present before *the* Royal Society his animated photographs of sound waves. There are many Royal Societies, Royal Astronomical, Royal Photographic, Royal Microscopical, Royal Society of Arts, and Royal What-Have-You, but there is only one Royal Society *tout court*—founded in 1660 and unquestionably the most important scientific body in the world. Professor Snow was greatly excited and took the matter up with President Adams, who took it up with the Regents of the University, and Wood was given a two months' leave of absence.

Boys met him on his arrival in London, put him up at the Savile Club and the Athenaeum, and secured suitable "lodgings" for him just around the corner from the former. His lecture before the Society of Arts was on St. Valentine's day, with Sir William Abney in the chair. But the great occasion was still to come. . . .

The young American professor's appearance before the Royal Society was scheduled for the following afternoon. Boys had finally located and set up a motion picture projecting machine, of which there were then only two in London.

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When they entered the sacred portals, the Fellows of the Society were having tea in the noble assembly room from which they all presently proceeded to the auditorium. Lord Lister, the venerable father of antiseptic surgery, presided from a thronelike chair behind an elevated desk. The great gold mace of Cromwell's time was brought in on a red velvet cushion and laid solemnly on the desk in front of the president. Cromwell had treated it with less formality, and his celebrated order, "Remove that bauble!" has echoed down the ages.

In the audience sat many of the great scientific celebrities then alive in London: Crookes, Dewar, Sir Oliver Lodge, and Lord Rayleigh. In a moment they would be listening to "a young man from Wisconsin," who would be standing where stood Isaac Newton, Davy, Faraday, and all the great in Britain's scientific history. But if you think all this overwhelmed our young man from Wisconsin, you don't yet know him. Says he in his notes: "I showed them the sound-wave photographs and moving diagrams without a hitch and spoke extemporaneously, feeling no more embarrassment than when lecturing to my students at Madison."

Nonsense! Actually, he was acutely aware of the tremendous honor, and he was undoubtedly boiling with excitement. For it was the dawn of world-wide fame.

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CHAPTER EIGHT

Early Years as a Professor at Johns Hopkins—Great Discoveries and Promethean Celebrations

Following the death of the great, gruff Henry Rowland at Johns Hopkins in 1901, Wood was offered and accepted a full professorship in experimental physics there. It was a high honor for so young a man, no matter how fantastic a genius. Gertrude went ahead to Baltimore and selected a house on St. Paul Street in a city block that had looked upon the stoning by secessionists of the Massachusetts regiment on its way to Washington. Returning to Madison, the furniture was packed up and sent on in care of the Baltimore house agent, who installed it on its arrival. The family reached Baltimore late in September. They opened the Baltimore house, unpacked the crate containing the Stanley Steamer, and bounced over the cobblestones with which the entire city was then paved. Surface drainage disposed of all the water used for washing purposes, a thin stream, sky blue on wash day, running out under every back gate and along a shallow gutter in the brick sidewalk. Loose bricks acted as force pumps, squirting a jet of water up your trouser leg almost to the knees if you stepped on one, efficiently adjusted with respect to its neighbors. Wood called them "bath bricks." The alleys and some of the street crossings had high stepping stones on which you crossed dry-

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shod in case of heavy rains, but at which the Stanley Steamer shied.

Of his work at Johns Hopkins, Wood says:

My teaching was very light, three lectures a week on physical optics, the same as at Madison, and I gave practically all of my time to research, a part of it in collaboration with graduate students working for the doctor's degree. With J. H. Moore an investigation was made of the green fluorescence of sodium, with more powerful spectroscopes than the one I had used at Madison. This came along very well, an "infant phenomenon" being observed that became very important when it grew up in later years. Instead of illuminating the vapor in a small glass bulb with white light as I had done at Madison, we shot into it various colored rays in succession obtained by a combination of lenses and prisms called a monochromator, which sifts out from sunlight a very narrow region of the spectrum and projects the beam of pure color at any desired point. We found that when the metallic vapor was illuminated by a beam of blue light, it emitted fluorescent light of a yellow color, but as the color of the beam from the monochromator was changed to bluish green, green, and greenish yellow in succession, the region of maximum intensity in the fluorescent spectrum moved down towards the region of the exciting light and eventually coincided with it, with a suspicion of a trace of light on the further side of it. This was an exception to Stokes's law of fluorescence, which stated that the light emitted by fluorescent substances was always made up of wave lengths longer than that of the exciting ray, that is, on the red side of it. Many years later unusual fluorescence was very clearly demonstrated in experiments that I made with sodium and iodine vapors, the discovery being of considerable importance in connection with the theory of molecular spectra.

While the sodium vapor investigation was in progress I was at work on several other problems, one having to do with the

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remarkable optical properties of a chemical with a terrifically long name, nitrosodimethylaniline, which was one of the substances we had been required to make in Professor Remsen's course in organic chemistry ten years before. It had struck me at the time that the bright green flakes with a metallic luster looked interesting, and I had preserved the material in a bottle. In the course of my lectures at Madison I had come to the subject of anomalous dispersion, shown by substances having strong absorption. A prism made of such a substance produces a spectrum in which the colors are not arranged in the same order as they are in the rainbow or in a spectrum formed by a glass prism, the deviation being greatest, but in opposite directions, for the colors close to and on either side of the absorption band. This phenomenon had previously been demonstrated and studied by solutions of aniline dyes contained in a hollow prism of glass. It had occurred to me that if I could fuse the pure dye and press it between two pieces of plate glass inclined at a small angle to each other, a much greater effect would be produced. I tried it with some crystals of cyanine, the dye used for sensitizing photographic plates for infrared rays. They melted easily and made beautiful prisms, which gave the effect in a greatly enhanced degree. Trials then made with about fifty other dyes showed that all were useless; they decomposed and swelled up into a spongy black mass without fusing, and I have never been able to find anything else that answered the purpose. Even cyanine made by other chemical plants would not melt. My sample was what horticulturists would term a "sport," I suppose. Ehrlich had 605 failures before the successful 606th. I had one success followed by fifty failures! In looking over my preparations made years before in Remsen's course I ran across the nitrosodimethylaniline green flakes. These green flakes melted at low temperature and gave beautiful prisms, which transmitted the red, orange, yellow, and green rays in normal order but gave a spectrum fifteen times as long as the spectrum produced by a glass prism

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of equal angle. Moreover, in solution, the substance absorbed the violet rays powerfully but transmitted the ultraviolet, and by combining it with dense cobalt-blue glass I obtained something that had been searched for in vain—a ray filter that would be opaque to visible light but transparent to the ultraviolet. With this filter I made my first landscape and lunar photographs in ultraviolet light, and at the autumn meeting of the National Academy in Baltimore in 1902 I gave an experimental demonstration of what could be done with what is now called black light.

The meeting was held in the lecture room of the physical laboratory, and after the exhibition of various photographs made exclusively by ultraviolet light, the room was completely darkened and the invisible rays from an arc lamp in a light-tight iron box were passed out through a single window made of the filter combination opaque to visible light. A white porcelain plate held in front of this window was invisible. The rays were brought to a focus by a large condensing lens on a pile of crystals of uranium nitrate, which immediately glowed with a brilliant yellow-green light, of sufficient intensity to read by. Newspaper accounts of the meeting record that this experiment "was received by a burst of applause, a reception rarely accorded at dignified Academy meetings."

Wood never denied himself the chance to make grandstand demonstrations such as this, but he didn't let them interfere with his laboratory research. During 1902 alone ten scientific papers of his appeared in the *Philosophical Magazine;* and a German physicist wrote to an American friend at this time, "Wood—he produces like a rabbit."

In the summer of 1902 the Woods all went to San Francisco to visit Gertrude's parents, who had sold the house in Ross Valley and reopened their house at 1312 Taylor Street. A new addition to the family was expected about the middle of July,

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and Gertrude insisted that this was the obvious time for Robert to visit the Hawaiian Islands, where he had always wanted to go because of his father's early life there. Wood's protests against the infamy of a husband deserting his wife at such a time were pronounced "rubbish" by Gertrude, who finally persuaded him to abandon her. She would be perfectly all right with her mother, nurse, and the doctor to take care of her. In those days you always had your babies at home. Maternity hospitals were an unknown luxury.

Wood says:

So presently I found myself on a steamer heading out through the Golden Gate. The Islands in those days were quite free from the commercialization which they have undergone in the past quarter of a century. You could see real hula dances, while now I'm told they have an expurgated edition sponsored by the Eastman Kodak Company held every day for the benefit of tourists, in front of the beach hotels. I had one or two friends who lived in Honolulu and in a few days a lot more friends, for I was invited to a *mou-mou* party over a week end. The *mou-mou* was a native negligee, a single garment, or rather a long burlap gunny sack with three holes at one end, two for the arms and one for the head. On arriving at the large country house set back from the beach, I was informed that we were to shed our clothes and put on *mou-mous,* with nothing underneath. In this garment, which came down to your knees, you played a game of tennis or sat around tables with iced drinks, and then all went down to the beach for a swim, and then back under the trees, where the gunny sacks dried out in a few minutes, then another drink and another swim, then dinner all in *mou-mous* around a long table, with champagne, then another swim by moonlight, "and so to bed," all of the men in one big room and the women in another in a distant part of the house, and the "roll" called be-

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fore the lights went out to make sure that all were "present or accounted for" and that no one was A.W.O.L.

The tame spiders were terrifying, and were in practically every country house or bungalow on the Islands. They are non-poisonous and are never molested, as they destroy millions of mosquitoes and other insect pests. The body is the size of a small hen's egg, and the hairy legs spread out over an area the size of a large saucer. I had not been told about them when I visited Gertrude's cousin on the island of Hilo, and on going to bed, just as I was stooping over to blow out the candle, I was startled by the sudden impact on the top of my head of something that felt like a frog, which bounced off onto the floor and scuttled under the bed. Looking over the ceiling I discovered three more of the creatures lurking in the dark corners. This was dive bombing on a larger scale than in the hotel in Omsk, and I shouted for my host, as I did not feel secure even under the mosquito net which covered the bed. He explained that they were pet spiders and lived on mosquitoes, and would eat out of your hand. Not out of mine, however!

I found that the Royal Hawaiian Hotel occupied the site of my father's former residence. It was a rather unattractive commercial travelers' sort of place, and has now, I believe, been replaced by something more suited to the rich tourist class. The Moana at Waikiki Beach was the swank hotel at the time, and it was here that I had my first experience with surfboards. Later on after we had acquired our summer home at East Hampton in 1908 I made surfboards for myself and friends and started that sport on the beach. It spread like an epidemic along the southern shore of Long Island and finally all over the map. As far as I know this was the first time the boards were seen on the Atlantic coast, and though it is very probable that I had many predecessors, it evidently had never "caught on" before, as in the case of my experiments with homemade skis when I was twelve years old.

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Bradford Wood,[1] one month old, was awaiting my arrival in San Francisco as I came back through the Golden Gate, with a basket of tropical fruits for his mother, all of which were confiscated at the customhouse, only just become bug conscious.

Back in Baltimore in the autumn of 1902, Wood continued his photography of the moon with invisible light. The contrasts between the dark and light lunar areas were much greater with ultraviolet than with visible light, while the reverse occurred in the case of landscapes. One interesting peculiarity of the landscapes taken in full sunshine was the almost complete disappearance of shadows, showing that the greater part of the ultraviolet rays came from the blue sky and not directly from the sun.

Later on at East Hampton he improved the method by employing a quartz lens with a heavy deposit of metallic silver, which is remarkably transparent to a very narrow range in the ultraviolet and quite opaque to all other rays. With this filter he discovered a large dark area around the lunar crater Aristarchus, which was practically invisible to the eye. Comparison experiments with terrestrial substances indicated that it was sulphur. The Germans named it the *"Woodsche Fleck."*

In a picture made with the silver filter a man walking in sunshine was accompanied by no shadow, like Peter Schlemihl in the German fairy story. Distant hills, clearly visible, were blotted out by atmospheric haze when photographed by ultraviolet. Wood later photographed with an infrared filter which showed distant mountains sharply outlined with all their high lights and shadows on days when the haze was so thick as to make them quite invisible to the eye. These later photographs, made in 1908, were the first infrared pictures ever taken.

In the summer of 1903, the Woods rented a cottage at North

[1] Bradford Wood died at the age of two and was buried in the family plot in Sleepy Hollow Cemetery, Concord, Mass.

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Haven, Maine, where a number of their new friends in Baltimore spent their vacation. Wood devoted himself to sailing, either in Dr. Stewart Paton's yawl or in his own dinghy. North Haven was a small village on the island of the same name, south of Mount Desert. At the other end of the island was the still smaller fishing hamlet of Pulpit Harbor. Here apparently daylight-saving time was invented, at least so Wood asserted when making an address years afterwards following a dinner given by the London Physical Society, at the time when the subject was under violent discussion in England. This is the story, as Wood tells it.

One afternoon some of us decided to walk across the island to Pulpit Harbor. When we arrived no one was in sight except an old fisherman mending a lobster pot in the sun. We asked him what time it was, and he pulled out an old tarnished turnip of a watch and said, "Half past five." "Why," we said, "it can't be as late as that. We left North Haven at a little after three and it's only four miles." "Oh, well," piped the old salt, "you know we have *fast time* here in the Harbor." "What do you mean by that?" we asked. "Why, we keep our clocks an hour ahead of those over in the City [meaning North Haven]." "What's the idea of that?" we inquired. "Oh, I dunno," he replied. "I reckon it's 'cause night seems to come sooner. An' then, too, you see, in the wintertime, the women folk don't mind gitting up at half past four, but they'd hate like hell to have to git up at half past three."

Returning to Baltimore in the autumn, Wood went on with his work on sodium vapor. With the aid of a $500 grant from the Carnegie Institute, he had engaged one of his former graduate students at Madison, A. H. Pfund, to help him during the year, and with $1,000 from his mother to buy necessary apparatus, he started a quite new line of attack on the measurement of the dispersion of sodium vapor with a Michelson interfer-

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ometer—a bold and delicate undertaking. This was his most important investigation up to that time, and when the results were published in the United States, Great Britain, and Germany, scientists from all over the world congratulated him. Lord Kelvin, dean of British physicists, wrote him a warm letter praising his "astonishing and splendid" experimental results. Years later, when Dr. Karl Darrow presented Wood with the Ives Medal of the Optical Society of America, he cited this experiment as an example in saying that "the term, 'a Wood experiment,' has come to be employed of any which is distinguished by unusual ingenuity and efficacy, and especially if it is made by simple means."

Early in the summer of 1904 the Wood family sailed for France from Baltimore on the Hamburg-American Line, going directly to Paris for a visit with Gertrude's married sister, Alice Robbins. The Robbins apartment was on the Boulevard Montparnasse over the Café du Dôme, where Wood had his first taste of sidewalk café life on the Left Bank. Lionel Walden, the marine painter, Alexander Harrison, Jim Wilder of Honolulu, and Jimmy Sullivan, all artists, inducted the Woods in the gentle pastime of piling up white saucers on the tables along the front of the Dôme.

This entire outfit, Wood found, was going to Beg-Meil, a seaside resort near Concarneau, the Breton fishing village, for the summer, and the Woods decided to join them. Wood bought a two-cylinder Darracq touring car, upholstered in scarlet leather, which he said "buttoned up the back." You entered the tonneau or rear compartment by a little door; when closed it formed the back of the middle seat, which was hinged to the door. The French had to have a *strapontin* in their autos, of course. Wood called it the "Darracket" on account of its engine noise.

Concarneau was an artist's paradise, with its brilliantly painted tunny boats with their great colored sails and the smaller sardine boats with their gossamer veils of blue nets

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floating in the air from masts and spars to dry. Wood, who had for years entertained himself with water colors and drawings, plunged into oils, and spent a gay summer painting, swimming, and talking art with his Left Bank friends.

In September Wood attended the Cambridge meeting of the British Association for the Advancement of Science. Lord Rayleigh had asked him to make them a visit at "Terling," his country home near Witham, where he had his private laboratory, and promised to have some continental physicists as guests at the same time. It was Wood's first visit at an English country house and he had never heard of being "unpacked." For his demonstrations of various phenomena with sodium vapor and his diffraction process of color photography he had a large suitcase full of glass tubes and bulbs, longish pieces of dirty rubber tubing, lenses and prisms of various sizes, and a long gas burner made of an iron pipe pierced with many pinholes. These oddments were wrapped up in underwear and old rags, some of it none too clean, and it was not to be opened until his arrival in Cambridge. The valet took charge of Wood's luggage of course, and Wood joined the company at tea. Professor H. Kayser of Bonn, Germany's leading spectroscopist, with whom Wood had corresponded frequently, was a guest, also Professor Otto Lummer, another celebrated physicist from Breslau University.

When Wood went up to his room to dress for dinner, he found to his horror that all of his numerous pieces of rubber, glass, iron, and brass hardware had been unpacked and arranged in neat rows on the dressing table, alongside the combs, brushes, etc. It was an appalling sight! He found the old rags and undergarments that he had used to wrap up his instruments carefully put away in the lower drawer of a dresser. Wood says:

When dinner was announced, Lady Rayleigh came up and, signifying that I was to be her escort, took my offered arm.

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Professor Lummer glared his disapproval at what he evidently considered a violation of precedence and great presumption on my part. He was a *privat docent* somewhere, I believe, when I was only a student. Further and very strong disapproval of Lady Rayleigh's table arrangements was shown presently. A card with my name on it marked the place next to Lady Rayleigh's chair. Lummer looked at it and elbowing me along took his place behind my chair and announced in a fairly loud voice, "I think I will me here sit." Lady Rayleigh gasped in horror and gave me an agonized but half-amused look. "In that case," I said, moving along to Lummer's reservation, "with Lady Rayleigh's permission, I will me here sit." I have never forgotten the expression on the face of the venerable butler, who was standing behind Lady Rayleigh's chair during this drama.

Waking up early next morning, I thought I would slip out and make a water-color sketch before breakfast. The heavy curtains were drawn over the windows, but there was plenty of light to dress by, and there seemed to be some concealed gadget which had to be uncovered before the daylight could be admitted, so I started to dress in the gloom. Suddenly there was a loud rap at the door. I was in undershirt, drawers, and socks, but I leaped back into bed, pulled up the bedclothes to my chin, and waited to see what came next; a second rap, and then the door opened softly, and the valet tiptoed into the room. I turned over and gave a poor imitation of a sleepy yawn, for I am always wide awake and alert in a fraction of a second, even if aroused from a deep sleep. The valet glided noiselessly to the window, and drew the curtains. I yawned again and stretched out my arms. "Good morning, sir, and a fine day, sir," said the valet, after the manner of all English valets. "And how will you have your bath, sir?" "Cold," I said. "'Kyou, sir," said the valet and vanished silently. Presently a large circular tub was brought in, planted on the floor in the center of the huge bedroom, and its basement space filled from

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pitchers innumerable. "Anything more, sir?" said the valet. "No," said I emphatically, fearing that he might try to take me out of bed and bathe me, and thus discover the fact that I apparently slept in my underclothes. "Very good, sir. Thank you, sir." So I got out of bed, undressed, and got busy with the problem of how to take a bath in a circular tin platter six feet in diameter.

After breakfast, Lord Rayleigh took us out to his laboratories, which were in a wing of the house. Here I felt more at home, for it was much like my own laboratory only more so: homemade mercury air pumps, the glass tubes mounted on weather-beaten boards which had outlived their usefulness elsewhere. There was a profuse use of laths, string, and sealing wax, which delighted my soul, for I realized that it was with this primitive apparatus that England's foremost physicist had made his most important discoveries. Finally he turned to me and said with his warm and genial smile, "Professor Wood, I wonder if you could repeat for us here any of your very interesting demonstrations with sodium vapor." I said, "Possibly, if I can use your glass-blowing lamp and you have some metallic sodium." While I was busy blowing glass bulbs, Lord Rayleigh was hunting for his sodium. There were endless glass cases, the shelves covered with cobwebbed bottles of chemicals of very old vintage. Finally I joined him in his search. "I have a jarful somewhere, but it seems to have disappeared. I'm afraid we'll have to give it up." As we walked along I spied, over in the corner of a top shelf, a glass preserve jar half full of yellowish liquid with some dark lumps in it. I opened the door and said to Lord Rayleigh, "I have a feeling that if this was *my* laboratory I should be inclined to keep my bottle of sodium about here," and reaching back with my arm, I drew out the dust-covered jar. "Ha, ha," said Rayleigh, his eyes twinkling, "I believe you *have* it! There seems to be nothing about sodium that you can't discover, even its hiding place." So we went at it. I loaded the bulbs with the metal, pumped

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out the air, and sealed them with flame; formed the colored deposits; and showed the remarkable color changes produced by local cooling. I then got my long gas burner, and in half an hour set up the demonstration with the long sodium vapor tube showing anomalous dispersion.

As we were walking back to lunch Lord Rayleigh turned to Professor Kayser and said, "Well, we have had a most interesting morning." "Yes, indeed," said nice old Kayser, "very, very interesting." Lummer, who was walking beside us, thrust his hand inside the breast of his long frock coat, threw back his head, and sniffed. *"Was mich anbetrifft, ich habe nichts Neues gesehen"* (As for me, I have seen nothing new).

At the end of our visit we were all taken over to Cambridge and quartered in the college dormitories. Arthur Balfour, Lady Rayleigh's brother, was the president of the Association that year and gave the opening address. The meeting then broke up into sections, and the members read their papers or showed their new tricks. I had set up half a dozen or so demonstrations with sodium vapor which were kept in continuous operation with the help of two student volunteers; also a row of transparent photographs in color, made by my diffraction process. There was a crowd milling around the tables most of the time. Lummer was further down the hall in a small dark room, showing the fine structure of the green mercury line with one of the interferometer plates that he and Professor Gehrke had recently developed. I was very much interested in it and stopped in later in the morning. There was only one other visitor, so I was given full opportunity to show my interest by asking all sorts of questions, which, however, were answered in a slightly haughty manner. Later on, a Cambridge don came up to me and said, "Oh, I say, what sort of a chap is this fellow Lummer? He's grousing to everybody about everyone's crowding into your show and not coming to his, which he says is far more important!"

The afternoon session of the physics group was crowded.

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Lord Rayleigh was the chairman, and there were some eight or ten prominent physicists seated on the platform. There was one vacant chair next to Lord Rayleigh, who caught my eye, smiled, and pointed to the empty chair. As I was half way back and the room had quieted down for the opening, I shook my head, but he pointed to the chair again and beckoned me to come. Slightly embarrassed, I walked up the aisle, climbed up on the platform, and sat down. Then, to my amazement, I saw Lummer, who was also seated far back, leap to his feet and advance toward the platform, on which he seated himself with his feet on the floor, determined to occupy, at all costs, his "place in the sun." When the time for my paper came, Lord Rayleigh, in announcing the title, added with an amused smile that I had even succeeded in discovering the missing bottle of sodium in his laboratory after he had searched for half an hour with no results.

On his return from France in the autumn of 1904, Wood moved all of his spectroscopic apparatus from his room on the ground floor to a small room in the tower of the laboratory that supported the dome of the Johns Hopkins astronomical telescope. Here he was able to have sunlight all day, as he was above the shadow of McCoy Hall, which was just across the street. The light of the electric arc which he had used for the study of the fluorescence during the previous year was not intense enough for the complete solution of his problem, but with sunlight he had high hopes of bringing out some new and interesting phenomena.

The American Academy of Arts and Sciences in Boston had given him a liberal grant from the Rumford Fund, which enabled him to construct a large and powerful spectrograph, with three huge prisms of dense flint glass five inches square and large achromatic lenses. These were mounted on a rigid metal frame of steel rods and aluminum, together with the slit and plate holder, and the whole was placed in a cheap, un-

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painted pine box, the shape of a grand piano. This design was characteristic of all his subsequent apparatus. He didn't care how the apparatus looked on the outside, provided that the concealed optical parts were of the highest perfection. A later instrument he called his tombstone spectroscope, as its base was a slab from a cemetery. His object now was to amplify the results that he had obtained the previous year with Moore, namely, that, as the color of the light employed in exciting the fluorescence of the sodium vapor was slowly altered from the blue to yellowish green, the region of maximum intensity of the fluorescent band spectrum was shifted in the opposite direction, i.e., from yellow to green. The simple steel tube used in the previous work had to be recharged with sodium after an operation of an hour or so, owing to the comparatively small amount of metal that could be used and its rapid distillation to the colder parts of the tube, where it hung in festoons of black spongy material from the wall of the tube. Cleaning the tube was a hazardous operation, as the metal had formed an explosive compound either with the hydrogen or nitrogen or both. The glass windows were removed and the tube was stood on end against the wall of the laboratory in the back yard. A pailful of water was then poured from a second-story window down into the open end of the tube. This operation caused a rapid series of terrific explosions, with great belches of yellow flame, which sometimes brought policemen into the vicinity in search of the lawbreaker who was discharging firearms within the city limits.

Says Wood:

To avoid these frequent annoyances to the police, I arranged a hollow three-inch drum of steel, which fitted snugly into the long steel tube, and had two small apertures, one for the entrance and the other for the exit of the concentrated beam of colored light. This drum was three-quarters filled with fragments of sodium before its introduction into the large tube,

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and the tube could now be operated for a hundred hours before it was necessary to clean it out and refill it.

Sunlight, reflected from a heliostat on the window sill, was focused on the slit of the monochromator, and the colored radiation emerging from the second slit was focused on the front aperture of the drum, forming a colored spot of fluorescence where the rays entered the sodium vapor that was streaming out through the aperture. An image of this spot was formed on the slit of my new spectrograph, by means of a mirror and condensing lens. The spectrum could be observed visually or photographed, and the changes in the distribution of the intensity as the prisms of the monochromator were turned, altering the color of the light thrown into the tube, were very remarkable. With blue-light excitation of the fluorescence, the spectrum consisted of two or three narrow yellow bands, but as the color was changed to blue-green and then to green, new bands appeared in the fluorescence spectrum which widened rapidly on the green side until it met the narrow band of the exciting light and finally extended beyond it on the short wave-length side, a certain and very striking exception to Stokes's law of fluorescence. The very crude theories of fluorescence which had been developed up to this time broke down completely in this case, indicating clearly that the physical processes concerned in the case of fluorescence were enormously more complicated than had been assumed.

And now came the greatest discovery of all. Observing the spread of the fluorescent spectrum from yellow through green to blue, as the color of the exciting ray was slowly altered from blue to green, I thought I saw a slight trace of a fluttering movement in the broader bands in the green. Narrowing the slits of the monochromator, which made the exciting ray more nearly of a single wave length (purer color), to the point at which I could just barely see the fluorescent spectrum, I threw a black cloth over my head and the spectrograph, and saw to my amazement, in place of the more or less continuous spec-

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trum of bands, a series of sharp narrow lines at regular intervals, like the divisions on a measuring stick. On slowly turning the screw of the monochromator which rotated the prisms and altered the color of the exciting light, the lines of the fluorescent spectrum appeared to be in rapid motion, vibrating to the right and left, the appearance being not unlike that of moonlight on rippling water.

The sight of a spectrum with lines wavering to and fro with an undulating motion was as unbelievable as would be the sight of a foot rule on which the divisions of the scale were moving about in an irregular manner. Closer observation showed that the lines were not actually moving, but were disappearing in one place and appearing in another. I now had a method of causing the appearance of various groups of widely separated lines in a complicated band spectrum of thousands of closely spaced lines, a method that would greatly simplify the study of these very imperfectly understood spectra. To cite another analogy from acoustics, it was as if one trying to form a theory of the structure of a piano by listening to the noise produced by slamming a board down over the entire keyboard had suddenly found that the keys could be struck successively or in groups.[2]

Wood was jubilant as Archimedes! He had no bathtub to jump out of. But he wanted to celebrate, and did, in a manner which terrified the eyewitnesses and stampeded a mule team.

Never before (Wood says) had anyone ever seen the lines of a spectrum jiggle about in this manner. And just then a black cloud came over the sun, and there was a rumble of dis-

[2] This was the starting point of some of his most important investigations in what Wood termed "resonance spectra," for which the theoretical physicists could not even suggest a plausible explanation. With the advent of the Bohr theory of energy levels in atoms and molecules, their explanation was at once evident, and as Wood had foreseen, their study was of the utmost importance in connection with the newer theory of band spectra.

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tant thunder. The storm came up rapidly, and in a few minutes it was so dark that lights went on in many of the rooms across the street. Then the rain came, a cloudburst, and soon a muddy torrent which stretched from curb to curb was running down the hill. A crowd had sought shelter from the rain in the wide porch of McCoy Hall across the street, and I suddenly thought of a splendid way of celebrating my discovery.

The thunder crashes were following the lightning at intervals of only a second or two. From my bottle of metallic sodium I picked out a lump the size of a small hen's egg and, opening the window, waited for another lightning flash. A Negro was driving a cart up the grade against the wind and muddy stream half a block away, lashing a decrepit horse. Presently a terrifying flash occurred. I threw the metallic ball down, and it struck in the middle of the street, going off with a gigantic yellow flame and a bang that were coincident with the retarded detonation of the thunder. The crowd in the doorway fled precipitately into the building, and the Negro hurriedly turned his horse and cart and dashed off full speed down the hill, looking back over his shoulder at the volcano of yellow fire that was floating on the surface of the water and pursuing him.

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CHAPTER NINE

High Lights, Side Lights and High Jinks at Johns Hopkins in the Years Between 1905 and 1910

EARLY in 1905 Wood finished the monumental work on physical optics which was destined to make him an outstanding authority on all subjects connected with light. The manuscript of *Physical Optics* was in the hands of Macmillan, destined to appear officially in the autumn of the same year, but it was due in the meantime for the oddest "prepublication" in the history of scientific books. Here's what apparently happened.

In 1905 the Wood family spent the summer again in France. Just as they were leaving Paris for Brittany, an enormous bundle of galley proofs arrived from New York. Wood dumped them in the Darracq, to be corrected and mailed en route. The Macmillan Company claims with truth the first official publication, but it seems to have appeared previously, "serially" and uncopyrighted, dipped into with amazement by tourists, in hotel privies and backhouses scattered all over Normandy and Brittany. Not caring to bother with the two sets of duplicates of the galley proofs, he had tossed them into hotel wastebaskets, as he mailed the corrected set back, in installments, to New York. Motoring to Paris over the same route two months later, they found large sheafs of *Physical Optics* hung on nails as toilet paper in many of the inns where they had previously stopped.

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Weird extracurricular excursions, alarms, and adventures kept occurring to Wood and his brain children when they returned to Baltimore, despite the steady progress of his serious scientific work. One of these occurred when a wealthy Baltimore engineer by the name of Otto Luyties conceived what may have been the first practical idea in the world for experiment with helicopters and invited the by now famous Johns Hopkins professor to aid him in matters of theory. Since Luyties was paying all the expenses, Wood agreed cheerfully to lend all the "theory" he could.

At that period (says Wood) Lord Rayleigh's collected works were my Bible. He had shown by calculations that the weight that could be raised by an engine or motor of *given horsepower* could be increased indefinitely by increasing the diameter of the airscrew. I verified these predictions by mounting a large electric motor, with its axis vertical, on a platform scales and attaching airscrews (or propellers of thin wood) of different diameters directly to the projecting axis of the motor. The blades of the largest one employed barely cleared the walls of the room, and registered the highest lifting force on the scales. Small models were made, driven by rubber bands, which rose in the air and sailed off in horizontal flight.

Presently Luyties built one whose horizontal propeller looked like a windmill about twenty feet in diameter. It had a twenty-five horsepower motor, and in May, 1907, they took it out to Sparrows Point for a trial flight.

Wood said, "Who's going up?"

Luyties said, "Not me. I've engaged a parachute jumper who will do anything for fifty dollars."

The propellers were of canvas like the sails of a Dutch windmill or the jib on a yacht. Just then the parachute jumper came up and Wood said, "Are you really going to do this?"

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"Sure," the parachute jumper said, "for a hundred and fifty dollars I'd do a bomb ascension!"

Wood wanted to know what that was, and the jumper said: "I go up in a balloon, drop with a parachute, and have a string about forty feet long below my legs on which a bottle of gunpowder explodes. Once the string got tangled up, the bottle exploded between my legs—and look at my scars! I will still do a bomb ascension for a hundred and fifty dollars, so why shouldn't I do this for fifty?"

The helicopter was on the wagon scales, and the parachute jumper was on the helicopter. The engine started. The sails filled out. Wood says it was lovely. It looked like a merry-go-round. It finally trembled, lifted a hundred pounds of its own weight off the scales, but remained otherwise stationary. Wood says the parachute jumper got his fifty dollars—but he doesn't feel that he himself was quite so well treated. While it was about to go up, it was Luyties's machine and Wood was only a "theoretical adviser." But when it came out in the Baltimore papers next morning, it was Wood's machine that had failed to rise from the ground.

Wood also participated in many of the more serious, sometimes successful and sometimes tragic aviation experiments in those pioneer days. One of these was with his friend Lieutenant Thomas Selfridge, who was subsequently killed in the ill-fated flight at Fort Myer with Orville Wright, in the autumn of 1908—just a week after Selfridge had been a house guest of the Woods at their summer place on Long Island. On Selfridge's invitation, Wood had made a trip with him to Hammondsport, New York, where Glenn Curtiss, Selfridge, and McCurdy had been financed by Alexander Graham Bell to develop a power-driven plane.

They had just finished constructing the *June Bug,* he says, and were making short daily flights in a straight line. They hadn't been able yet to make circular flights, principally because the *June Bug's* engine, which was then air-cooled, over-

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heated too quickly. Wood, remembering his own laboratory expedients for cooling off red-hot sodium-vapor tubes, told them that if they packed the cylinders in cotton wool drenched with water, the engine would keep cool longer. Curtiss thought the idea was absurd, even as a temporary expedient, and vetoed it. Wood, always insistent when he believes he's right in matters of that sort, proved his point conclusively with tests made on the engine of Curtiss's six-cylinder racing motorcycle in the laboratory there. Before they were able to use this method with the *June Bug,* a water-cooling system had been worked out, making the longer circular flights possible. Wood, who had flown in Lilienthal's glider, wanted at this time to make a solo flight in the *June Bug,* but the plane was "wavy" and dangerous, and Curtiss wasn't wanting any needless dead celebrities strewn around his field.

Another of his extracurricular—but in this case completely successful—scientific stunts during this period was the invention of the so-called "fish-eye" camera. Long years before, while poking around under water in the primitive diving helmet he'd made with a wooden pail, he had suddenly said to himself, "I wonder what the world looks like to a fish. . . ."

In discussing refraction in his lectures on optics, he had always taken up the view which the submerged swimmer gets when his eyes are directed upward to the surface of still water, which appears as if covered by a dark ceiling with a circular sky-lit window directly overhead. The entire sky from horizon to horizon is compressed into this window and all objects surrounding the pond, trees, houses, fishermen, etc., should appear around the edge of this circle. The water is, however, always rippling from the disturbance due to the swimmer's descent, and the eye does not focus well when submerged, so it is next to impossible to see any trace of what should be a sharp, though somewhat distorted, picture embracing an angular aperture of 180°. Wood had looked for this in vain with his

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wooden-bucket diving helmet at Cataumet many years before, forgetting at the time that the rays from the horizon, which are refracted down at a steep angle on striking the surface of the water, are bent back into their original direction when they enter the air inside of the helmet, through its glass window.

It occurred to him, however, during one of his lectures, that by immersing a camera—plate, lens and all—in water and waiting for the ripples to subside before making the exposure, a sharp photograph of the phenomenon might be obtained. After a few preliminary experiments with a tin lard pail furnished with a horizontal opaque diaphragm and filled with water, he constructed what he named the fish-eye camera. A brass box was made measuring five by six by two inches, into which a photographic plate could be slipped through a slot in the side, which was then sealed by a rubber gasket. The box was then filled with water through a small hole, closed by a screw cap. The optical system consisted of a small square of plate glass backed by an opaque film of silver covered with varnish, in the center of which he made a minute circular window, by scratching off the opaque film. This plate was cemented over a small hole at the center of one side of this box, glass side up. This was covered with a hinged lid, which served as a lens cap for making the exposure. The surface of the pond was represented in this case by the outer surface of the glass plate, the pinhole aperture forming the image on a photographic plate which was immersed in the water with which the box was filled. This was in effect a camera with the equivalent of a lens of a working angle of 180°, and it could be pointed in any direction, up, down, or sidewise.

As his first subject he selected an overhead trestle bridge, which carried the streetcars across the railroad yards at the Monument Street crossing. This should give a good idea of how an overhead bridge appears to a fish in a quiet stream below it. Placing the sinister-looking black box on the ground,

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he was annoyed to find himself surrounded by an interested group of colored children, who had followed him to see what it was all about. As they would of course ruin the picture, he told them to clear out, an order which was greeted by giggles. An exposure of a minute would be required, and Wood suddenly had an inspiration. Lighting a match, he held it against the side of the box, shouting, "Beat it, or you'll be blown sky high," and raising the lid of the box, he hurried away. The crowd scattered in all directions, and at the end of a minute he returned, closed the lid, and strolled back to his laboratory.

While the scientific significance of the fish-eye camera was given to the world in the British *Philosophical Magazine* and other technical journals, our *Literary Digest* and the *Illustrated London News* took it up from the point of view of the fish—particularly the fish in aquariums who seem generally to stare just as much at us as we do at them—and probably think we're just as queer.

In 1908, the Woods bought the old Miller farmstead, with its pre-Revolutionary house and huge barn and its remaining five acres of land, near the seashore in East Hampton, Long Island, far out toward Montauk Point. There are deeds of conveyance dating back to 1771, and the hand-hewn beam structure of the buildings indicates that they too may date back that far.

Wood transformed the immense barn and its adjacent cowshed at East Hampton into a summer laboratory. Both here and at Johns Hopkins, he was absorbedly at work throughout these years—despite diversions and digressions—with new experiments, discoveries, and inventions. He later invented and installed beneath the cowshed the mercury telescope which made a world-wide sensation; he also built the largest spectroscope (or spectroscopic camera) in the world, and cleaned it of spiderwebs with the unwilling co-operation of the family cat.[1] He took aerial photographs by sending a camera up on a

[1] *See* Chapter X.

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kite and releasing the shutter with ordinary firecracker punk. He made the further steps which were to mark a high light in his career by resuming and improving the photography of the moon with invisible ultraviolet light, which he had begun back in 1903.

He also took terrestrial time out, as it were, to debunk the complicated theory evolved by purely academic physicists to account for the high temperatures obtained in conservatories and greenhouses, which had crept into nearly all textbooks that mentioned the matter at all. It is well known that glass is quite opaque to the greater part of the sun's spectrum beyond the red, that is, the region of longer wave lengths. The old theory considered that the visible light and shorter heat waves passed through the glass and heated the ground. The ground, thus heated, was supposed to give out radiation of such long wave length that it could not pass through the glass and was therefore trapped.

Wood's theory was merely this: the glass house lets in the heat rays, which warm the ground, which in turn warms the air. This warm air is shut in by the house, instead of rising to the clouds as it does in the open. If you leave the doors of a greenhouse open, what becomes of the old theory?

He proved his case by the following very simple experiment. Constructing two enclosures of black cardboard, he covered one with a glass plate and the other with a plate of transparent rock salt. The bulb of a thermometer was inserted in each enclosure, and the apparatus exposed to sunlight. The temperature rose to 130° Fahrenheit, practically the same in each bulb. The rock salt is transparent to practically all of the heat radiations concerned, and on the old theory the enclosure covered by this material should not show the greenhouse effect, that is, there would be no trapping of radiation and the temperature of the enclosure would be much less.

In December, 1908, Wood was called upon to give a public lecture dealing largely with color and its application to paint-

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ings (the word "color" here refers to light rather than to pigments). Partly as a demonstration to enliven this lecture and partly because he thought it might have some use in stage lighting, he had worked out an optical method for the intensification of the color of paintings. Wood had occupied himself with the painting of landscapes in oil for some time as a diversion and had frequently noticed that a spot of sunlight, coming through chinks in the foliage and falling upon a green meadow in the picture, had produced a pleasing effect.

It occurred to him that if this enhancement of the illumination could be applied to all of the high lights in the picture in proper proportion, there would probably be a startling increase in the brilliancy of the picture. The whitest paint is only about sixty times as bright as the darkest paint ever employed by artists, whereas the ratio of intensity of sunlight on a white building to the deep shadow of a doorway may be as much as a thousand to one.

He found a way of intensifying the light contrasts in paintings by photographing the original painting, preparing a lantern slide from the negative, and projecting it with a lantern placed at such a distance as to secure exact registration of the image on the original. In this way, a powerful illumination was thrown on the high lights and a feeble light on the shadows, with all the intermediate gradations correctly controlled. The effect in a dark room is quite startling—a landscape fairly glows with sunlight. After viewing it for a few minutes, if the lights in the room are turned up and the lantern turned off, the picture looks as if it had not been dusted for years. The audience was amused when a large portrait of a prominent trustee was illuminated in this way, and Wood found that by joggling the projecting lantern the pupils of the portrait's eyes glanced rapidly back and forth from right to left in a most lifelike manner.

Wood saw a possible practical use of this discovery in connection with stage effects, in which the painted backdrop could

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be illuminated by a lantern in the gallery which projected upon it a photograph made in a similar manner. This, he thought, should be particularly effective in sets which were supposed to be drenched in sunlight.

Wood's most important work, however, continued to center around the optical investigation of sodium vapor. Examining the absorption spectrum of sodium vapor in the ultraviolet, he succeeded in increasing the number of lines of the principal spectral series from the eight previously known to fifty. It was, and still is, the longest spectral series known. This discovery was later cited by Niels Bohr as a beautiful proof of his new theory of atomic radiation, for which he received the Nobel prize. Another experiment of Wood's at the same time that was also important in the new theories of radiation was his demonstration that the fluorescent light emitted by sodium vapor (and potassium and iodine vapor as well) was polarized—that is, a large percentage of the light vibrated in a single plane. At the same time, Wood was working with one of his students, H. W. Springsteen, on magnetic effects on polarized light. Corbino, an Italian physicist, some years previously had noted that by placing a sodium flame between the poles of an electric magnet and passing a beam of polarized white light through it, the plane of polarization of some of the yellow light was rotated several degrees. Wood and Springsteen, working with metallic sodium heated in a glass tube instead of a sodium flame, obtained rotations as great as 14° in the yellow region, and discovered marked traces of rotation in other regions of the spectrum. Wood was to continue this work for a number of years, with more powerful magnets and improved technique, obtaining rotations as great as 1,440° or *four complete revolutions,* results of great value to the theoretical physicists.

In the summer of 1909 Mars was in opposition, and all the astronomers were on tiptoe. Wood took out the six-inch lens of his big spectroscope at East Hampton and mounted it on

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a block of cement on the lawn in front of his laboratory door. A silvered mirror reflected the light of the red planet through the lens and thence to an eyepiece forty feet away, at the back of the dark laboratory, where he viewed the magnified image of the planet while lying comfortably on the floor on an old mattress.

During this same summer he resumed his experiments on photographing the moon in ultraviolet light, and showed the possibility of getting some notion of the nature of the rocky surface of the moon by photography with light confined to selected regions of the spectrum. His first paper on the subject was communicated to the Royal Astronomical Society of Great Britain by Sir Robert Ball, the Astronomer Royal, and published in the *Monthly Notices* of the Society, from which I quote:

The preliminary experiments were made at my summer laboratory at East Hampton, Long Island, N. Y., with an improvised instrument made out of odds and ends. A thin film of silver, opaque to all visible light, transmits quite freely ultra-violet light of wave-length 3000, but these rays will not go through glass, consequently a lens made of quartz was necessary. A photographic telescope was made of a three-inch silvered quartz lens of six-foot focus mounted over one end of a piece of galvanized iron stove-pipe, with a plate-holder at the opposite end. This was lashed to a five-foot astronomical telescope which served for following the moon, during the three-minute exposure which was necessary. Both were attached to an equatorial mounting made of an old bicycle frame embedded in a block of cement, the steering axis pointing to the pole star. A slow motion enabled me to make exposures of several minutes if necessary. A more detailed description of this instrument will be found in the *English Mechanic* for November 12, 1909.

I had discovered an extensive deposit of some material which is dark in ultra-violet light, close to the crater Aristarchus. This deposit shows scarcely at all in the pictures made in yellow light, while it is nearly black in pictures made by light confined to the ultra-violet range around wave-length 3000.

Parallel experiments made in the laboratory showed that many substances which are white in ordinary light are jet black when

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photographed with these very short waves. Chinese white (zinc oxide) and most white garden flowers are good examples. These white flowers, if growing on a snow-bank, would be nearly invisible, and would not appear in photographs made in the usual way, but would be clearly brought out in pictures made with the quartz lens and the silver film.

In this same year, 1909, the American Academy of Arts and Sciences gave Wood the American gold Rumford Medal for his work on the optical properties of metallic vapors, and Clark University, at Worcester, Massachusetts, conferred on him the degree of LL.D., in company with other distinguished American and European scientists, including Freud and Volterra, the celebrated Italian mathematician. Wood has never taken his honors any too seriously, and here's what he says, recollecting the occasion.

After the rather heavy and solemn ceremonies were over Professor Webster, head of the Physics Department, invited us to his house for cheese and beer. As things dragged a bit, Webster asked me to show them a celebrated parlor trick I'd invented when a student at Johns Hopkins.

Lying on the floor one evening and watching the inverted face of one of the graduate students who was talking while standing up, I had been intrigued by the ludicrous expressions of the talking mouth when viewed upside down. In my imagination I pictured eyes and nose on the chin to complete a small face engaged in animated conversation. It was screamingly funny, and I at once got out my water colors and painted the eyes and nose in the proper position with respect to the mouth, laid a mirror flat on a table, seated myself before it, and covered the upper part of my face with a black veil, transparent enough to see through. By holding a mirror in my hand well out in front of me, I could see the reflected image of the little face right side up in the large mirror, and I recited Jabberwocky with many grimaces to observe the effect. It was a

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great success, and had been exhibited on many occasions to small but enthusiastic audiences seated in front of the mirror. After the performance in Webster's parlor was over and the laughter had died down, dear old Volterra came up to Webster and, shrugging his shoulders and holding his hands palms up in a gesture of despair, said plaintively, *"C'est plus gai ici qu'en Europe!"*

Despite metallic vapors, gold medals, hard work, and what-have-you, the Woods had been keeping things pretty gay too in summertimes at East Hampton. Believe it or not, our professor learned to dance the bunny hug and turkey trot, and is credited with a howling wisecrack when someone asked if he wasn't afraid of treading on the feet of the young matron who was giving him a lesson in the then new "close-up" clinches. "How can I?" he demanded, "when her feet are always *behind* me?"

Costume parties, barn dances, amateur theatricals followed one another in dizzy succession every summer, and each gave Wood a chance to demonstrate his ingenuity and high spirits. The "face on the chin" trick was elaborated into a vaudeville act by projecting it in color by a homemade lantern onto a huge white head made from a properly compressed pillow. (Ziegfeld later experimented with the idea.) But Wood probably got most fun out of an "aeroplane flight" that was the climax of a vaudeville show that the Woods put on in the famous barn. Here is Wood's account of it.

The feature of the evening was announced as an aeroplane flight from the roof of the barn. An iron wire had been fastened from a pole on the top of the barn, descending at a small angle all the way across the wide lawn to the front gate of the house. From this was suspended on two small steel roller trolleys a huge Weather Bureau box kite used in meteorological investigations, which had been sent to me as an aid in kite

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photography experiments. At the appointed hour I appeared on the lawn clothed in some ridiculous aviation suit, goggles, beard, etc. Introduced by a barker as Bleriot, the first man to cross the English Channel by air, I mounted a ladder behind the barn, climbed up over the roof, and hoisted the box kite over the ridge pole, with a straw man, clothed as I was, suspended below it. Lighting the stick of red fire between the fore and aft wings and giving the machine a push, I sank back out of sight behind the ridge pole. Away it went with a streak of red smoke behind and the trolley wheels adding their scream to the screams of the women which rose when the whole contraption—man, machine, and red fire—crashed into a bush by the gate.

Towards the end of this crowded year of 1909, Columbia University wrote to Wood asking him if he would care to be an Adams Research Fellow of Columbia. There was a fund left by Edward Dean Adams of New York as a memorial to his son, Ernest Kempton Adams, the income to be devoted to maintenance of a research fellow and the publication and distribution of the results of the research.

All that Professor Wood would have to do in return for the honorarium was to permit the publication of his papers by Columbia University in the form of a book, for the years during which he held the fellowship.

Wood accepted it and held the fellowship for three years. It enabled him to take a sabbatical in 1910-11, and again in 1913-14, Johns Hopkins University paying him half salary during the years which he spent abroad.

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CHAPTER TEN

Wood Sets Up the Mercury Telescope in a Cowshed—and Puts the Famous Cat in the Barn Spectroscope

Ding, dong, bell,
Prof is in the well.
What did he put in?
A basin full of tin.
What did he get out?
Nothing, just about.

Wood's invention of the so-called mercury telescope—a revolving dish of quicksilver at the bottom of a pit—was one of the most sensational, useless, and significant things he ever did. It was constructed on the principle that mercury in a shallow metal dish, when rotated, assumes the form of a paraboloidal reflecting mirror. The dish of mercury was placed at the bottom of a well beneath an old cowshed with a hole ripped in its roof, and rotated slowly by a motor while the observer at the top of the well looked down through an eyepiece lens at the enlarged, reflected images of celestial bodies as they crossed the zenith.

Wood had the machine built by Warner and Swasey of Cleveland, the celebrated makers of large astronomical telescopes. Every conceivable refinement had to be made to secure a smooth rotation of the dish of mercury, since any jar to the dish would cause ripples on the surface of the mercury and

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distort the images formed in the mirror. Wood had the brilliant idea of accomplishing this by surrounding the mercury dish with an independently mounted rotating collar, driven by an electric motor and attached to the mercury dish only by thin bands of rubber. These rotated the dish without transmitting the vibrations of the motor. The focal length of the instrument could be varied from four to fourteen feet by altering the speed of the motor. Standing at the edge of the well and looking down into it, one saw the images of the overhead stars, enhanced to the brilliance of distant arc lights, suspended in space at the mouth of the well—an especially marvelous sight when the great star cluster in the constellation of Hercules crossed the zenith.

On August 27, 1908, the New York *Times* gave the entire streamered front page of its Section II to a profusely illustrated piece entitled:

A NEW IDEA FOR READING THE STARS

Wood of Johns Hopkins at East Hampton Working on a Telescope that isn't a Telescope with a Lens that isn't a Lens.

On Sunday April 11, 1909, the Baltimore *Sun* eructed an even more sensational front-page spread, with black-and-white drawings of Wood looking like Tarzan, a huge hunk of cratered moon resembling Swiss green cheese, the ripped-up cowshed looking like a cowshed, and the diagramed gadgets in a cross section of the well beneath it resembling nothing then on earth, but presaging the cartoons that were later to make Rube Goldberg famous. The headlines were equally diverting.

New Telescope May Solve the Riddle of the Universe!

IS MARS INHABITED?

MERCURY REFLECTOR INVENTED BY BALTIMORE GENIUS TO BRING THE MOON WITHIN A FEW MILES OF EARTH

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The Associated Press and popular science syndicates went to town on it, while the cowshed became a shrine for pilgrimages of scientists and curiosity-seekers. It got on the cables. The French gazettes wrote about the *"Puits et Plancher Poulie";* the Berlin journals announced the epoch-making invention of *"Ein originelles Spiegelteleskop."* A couple of Teutonic astronomers made the pilgrimage, peered down into the well, exclaimed, *"Gott in Himmel! Wunderschön!"*

The idea which excited everybody was that if a twenty-inch dish of quicksilver at the bottom of an old well under a cowshed could work such wonders, then a twenty-foot dish down a mighty mine shaft, as it were, would bring the moon to Baltimore and the Bronx. Even the Boston *Transcript* began to get excited over signaling the Martians—though Wood himself, needless to say, had never made nor countenanced any such fantastic blurb-and-boloney bunk.

Arthur Gordon Webster, then head of the Department of Physics at Clark University, who was one of the first to visit East Hampton, had been humorously scornful of the mercury telescope, and had written in the Wood guest book the jingle which appears at the head of this chapter. The astronomer W. H. Pickering had come visiting later, and after Wood had resolved the quadruple star Epsilon Lyrae for him in the mercury telescope, he had written in the same guest book the following happy pun:

> When Epsilon Lyrae is *well* shown,
> Truth will not have searched
> Her mirror in vain.

His brother, the even more famous Edward Pickering, director of the Harvard Observatory, said, at the top of all the first excitement, "I think we'd better wait. . . ."

And Wood himself—who had found an old penciled record on the cowshed door, "Heifer calf, May 1860," and added in

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his own scrawl, "Mercury telescope, June 1908"—was in complete accord with Pickering.

Not so, however, the great Empire State of Texas. The Texans were all for signaling Mars instanter. The idea of waiting didn't appeal to them at all—nor to that late great religious-fundamentalist archaeologist, the Reverend Professor William S. Cole of Atlanta, Georgia, and the Bible Belt. He felt that God had inspired Professor Wood and that we might obtain even a glimpse of the Pearly Gates through the roof of the humble cowshed. Professor Cole had no financial backing and couldn't get going on his idea, but wealthy Texas began bombarding Wood with telegrams. The first one came from Fort Worth, was signed by the *Star Telegram,* and read: "What would it cost to establish plant in West Texas to observe Mars with your mercury reflection would you be willing to conduct experiment large uninhabited areas clarified atmosphere and altitude make conditions perfect."

On its heels the same day came another urgent wire: "Kindly let us know if you are willing to establish experimental plant huge mercury mirrors if all expenses guaranteed Stamford Texas will stand for ten thousand dollars perhaps more please answer."

When Dr. Wood replied declining the offer and explained to the newspapers and Associated Press that he hadn't the remotest idea of going to Texas or trying to signal Mars, the Texans frantically raised the ante to $50,000 and wired: "We will do all we can to help you and assure you we are in earnest."

Even this failed to melt the professor's heart. In fact he became a bit impatient and ironic. When prodded by the New York *Herald* about schemes for signaling Mars, including one which involved covering several square miles of desert with mirrors, he wrote in reply:

> As to the project of attracting the attention of the Martians to the fact that there are rational beings on the earth, it seems to me that if there are any who insist upon making us conspicuous in

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this way it would be better to devise some simpler way than the construction of a mirror several miles in diameter. A large black spot on the white alkali plains could be constructed at much less expense, and would be as easily perceived by the Martians, if they exist and have telescopes as powerful as ours. It would be as easy to "wink" signals with the black spot as with a mirror of equal size, probably easier.

The spot could be made in small sections of black cloth arranged to roll up on long cylinders, exposing the white ground underneath, the cylinders being operated simultaneously by electric motors. I am unable to say how much four square miles of cloth would cost. You will have to consult the dry goods houses or the people who write arithmetic.

We should probably get an answer, for the Martians are supposedly older and wiser than we are.

I have never, and am not now, giving any attention at all to the problem of signaling to Mars.

I don't think we need go any further to justify my adjective "sensational." Nor need we blame Professor Wood for the sensationalism. He has perpetrated some gigantic and Gargantuan hoaxes—as hoaxes—but is of a rigid, almost ultra-conservative integrity in the field of serious science. He had never sanctioned any of the fantastic and gratuitous predictions. Indeed, he had never claimed anything for the mercury telescope. He had merely invented it, and there it was. . . .

As for my second adjective, "useless" . . . well, the mercury telescope isn't there, or anywhere, any more. When the moon rises over the cowshed, no mirror flashes, no Katie waits, and no quicksilver gleams. It has gone the way of the heifer calf. It just didn't work out pragmatically. One thing I wondered about, and which may have had something to do with its demise, was how the hell you could *point* a hole in the ground at the particular planet, star, or galaxy you wanted to study at the time? Wood says my wonder is justified, and that later he mounted over the pit a twenty-inch plane mirror of silvered glass and was able to view objects which were widely removed from the zenith. I doubt if it could have helped much.

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Now to justify our third adjective, as to its being one of the most "significant" things Wood ever did. The method of driving the mirror with an independent circular rotor he subsequently applied to all of the dividing engines used for ruling diffraction gratings, and at once got rid of certain errors in the proper spacing of the lines. It has since become a standard engineering practice. So, despite its immediate uselessness, the whole thing was of an instructive significance, as an example of how your pure scientist sets himself a problem—which may or may not lead to practical results—and solves the problem by breaking it into its component parts and dealing separately with each. Wood's own technical description (written at the time and preserved in his scientific papers) of the problem, its motivations and the technique employed in solving it, is a clear, modest, and illuminating exposition of how the wheels go round—in the making of a mercury telescope and also in the scientific brain.

Before it went into limbo, the mercury dish mirrored one profound reflection, not of starlight but of rural American philosophy. It was during the Bryan-Taft campaign, and an old East Hampton farmer, after staring at the myriad stars reflected in the mercury telescope, sighed and said,

"Well, I don't know as it makes so much difference after all whether Taft or Bryan's elected. . . ."

The old farmer's reflection was profound, but was it *original?* Or have people been saying it since the time of Pythagoras?

Now while the mercury telescope was following the heifer calf into oblivion, Wood was already engaged in the construction—in this same unique barn-cowshed-laboratory at East Hampton—of a gigantic spectroscope, or rather spectroscopic camera, which was destined to become an entirely different kettle of cats. It was, and for years continued to be, the largest and best instrument of its sort in the world, and in addition to making the Woods' house cat as immortal as the parrot of Archimedes, it marked an epochal advance in spectral knowl-

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edge and analysis. One of the many things it did was to resolve for the first time the complicated spectrum of iodine, which has some forty thousand lines. But whenever this is mentioned by scientists and physicists, whether here or in Tokyo or Singapore, somebody always interrupts to tell the story of the cat, so I think I'd better follow custom and dispose of the Wood pussy. There are many versions of the story. It was twisted by *Time* a couple of years ago, and became a sort of feline Rin-Tin-Tin animal serial in the hands of the newspaper feature writers, who turned the cat into a permanent magician's assistant and had it regularly doing its stunt whenever Wood called, "Pussy, pussy, come and clean the cobwebs." It had, indeed, so many variants that I'm not sure Wood himself is any longer able to give a trustworthy account, and the cat cannot be interviewed because she's dead. Yet what apparently actually happened is simple and easily told. The spectroscope had a long wooden tube, forty-two feet in length and six inches or so in diameter, projecting out through the side of the barn, to an iron post in the cowyard, fitted at one end with a diffraction grating and at the other with a slit and a mirror. During the first winter and spring after its construction, the spiders got in and wove their webs. When Wood came down in June he spied the arachnean invasion. He grabbed the family cat and stuck it—not without a struggle—into one end of the tube, which he then closed up. Pussy, having no alternative, squirmed her way through the tunnel towards the daylight and bounded out at the other end trailing a bridal veil of spiderwebs over the fence and across the lawn. It hadn't occurred to the Professor that it would be long remembered, though he casually mentioned the episode in a technical paper in the *Philosophical Magazine*. It was just a quick, efficient, costless way of obtaining a desired result with whatever came nearest to hand.

This spectroscopic camera was a marvel of scientific—and practical—ingenuity. Friends, fellow-scientists, curiosity-seek-

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ers, and journalists again flocked to the now world-famous barn. There are many clippings, some highly technical, which describe what was going on there in 1912. The picture which comes clearest to me is the description which appeared in the Brooklyn *Daily Eagle* of Sunday, September 1, 1912, in which the writer said:

One passing along the road would never suspect that the place was other than a quaint building housing farm animals until the professor swings open the huge doors and shows you the interior.

The new spectroscope, which the professor built entirely himself, is essentially so simple a mechanism that one would hardly expect any startling results could be obtained from it. It consists of a long wooden tunnel, forty-two feet in length and seven inches square, terminating at one end in an achromatic lens, six inches in diameter, having a forty-two-foot focus, just the length of the tunnel. Beyond the lens, at the same end, is the diffracting grating which decomposes the light into the prismatic colors. This grating is a piece of polished metal ruled with diamond scratches, 15,000 to the inch, making a total of 75,000 vertical lines on the whole surface, which is five inches square.

The grating rotates on a vertical axis, turned by a rod and gearing wheel, so that the professor may use any part of the spectrum he wishes at a time. The instrument is so powerful that only a small part can be used at a time. The lines on the polished plate act just the same as a prism in diffracting or decomposing the light into the prismatic colors, but make the instrument much more powerful than an ordinary prism.

At the other end of the tunnel, which terminates in a dark room, is a small slit and back of that a mirror on which the sunlight is reflected from the outside by means of another mirror and a lens. This reflecting mirror and lens work as a heliostat revolving by clockwork, with the motion of the sun, so that the reflected light is always on the mirror at the dark end of the tunnel, which in turn always reflects this light through the slit to the achromatic lens and the diffraction grating. When the light is decomposed by the grating and sent back through the tunnel it is tilted slightly upward so that a photographic plate inserted just above the slit will take a photograph of the section of the spectrum on which the professor is working.

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The wonderful power this instrument has in diffracting color and decomposing the spectrum is shown in many ways, each of which manifests its superiority over previous spectroscopes and the results obtained by them. In the first place, the professor said, in a small laboratory spectroscope what is known as the yellow sodium line appears as a single line, while in this new spectroscope this same line . . . appears as two distinct lines, separated by a distance of 5 inches!

Furthermore, the entire spectrum as seen by this instrument would be 50 feet long, while the finished spectrum magnified three times in order to study the various spectrum lines would be 150 feet in length. This is the length to which the spectrum studied by Professor Wood is extended, although he is not interested in the entire spectrum but only one part connected with his study and research work.

Professor Wood is now making a study of the absorption spectrum of iodine in connection with some other work along the same lines which he did last summer.

Despite the unwilling co-operation of the family cat, the wooden tunnel of the original East Hampton spectroscope became unsatisfactory. Wood had built a shingled roofing along its full length. But rains and snow finally wet and warped it. So he decided to build a new tunnel underground, using sewer pipe. East Hampton had a stone mason and pipelayer by the name of Barnes, with whom Wood had been on terms of complete understanding since the episode of the baptismal font. There are various versions of that story too. Here's what Wood tells me actually happened.

Barnes was doing some work for us while we were renovating the place, shortly after its purchase. He was building the cesspool. One day when our own car balked, I rode downtown with him on the seat of his cart, with barrels and sieves rattling behind. As we were passing through the village, the new rector of the chapel at Amagansett came hurriedly toward us, holding up his hand as a stop signal.

"Good morning, Mr. Barnes. I trust, Mr. Barnes," he unctu-

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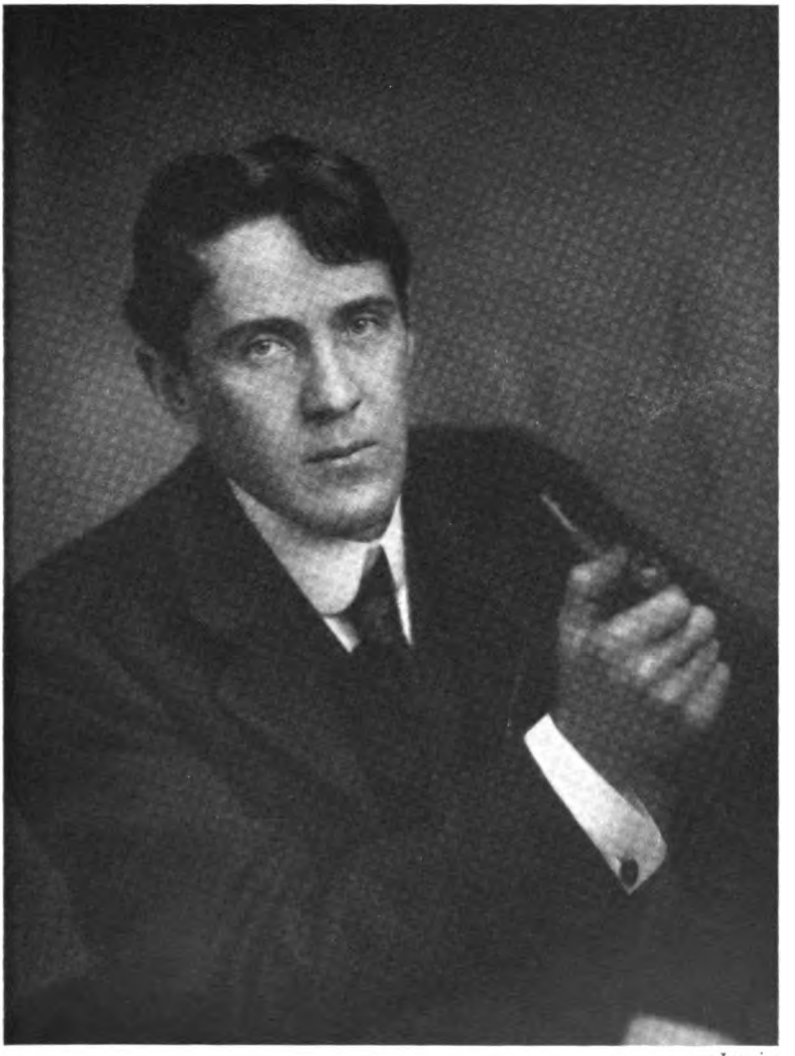

Janvier

JOHNS HOPKINS PROFESSOR: Wood in 1901, when he became professor of experimental physics at Johns Hopkins University.

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THE MERCURY TELESCOPE: Here we see the spinning bowl of mercury reflecting the face of Wood as he gazes at it. Since the mirror is concave, reversing reflected images, Wood's reflection appears right side up. This photograph was taken in the barn laboratory at East Hampton, where the preliminary work was done. Later the mercury telescope was moved to a pit under an adjacent cowshed.

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ously intoned, "that you will bear in mind that you promised to come to Amagansett at your earliest opportunity and lay our new baptismal font."

"Yes, Doc," replied Barnes, "I'll build your baptismal font soon's I can, but I got to finish the Prof's cesspool fust."

Barnes's comeback had so enchanted Wood that he sent for him later to build the new spectroscope tunnel. The problem, of course, was to keep the tunnel, built of terra-cotta sewer pipes with walls of irregular thickness, absolutely straight and smooth *inside*. This was a problem that had never confronted Barnes before.

Wood put a heliostat (a mirror operated by clockwork) in the pit at the end of the forty-foot trench, which reflected a horizontal beam of sunlight three inches above the trench bottom. He told Barnes to lay the pipes along the beam of light, each pipe being adjusted so that the circular spot of light was exactly at the center of a sheet of white paper held against its end. When the job was finished and viewed from the outside, it seemed as full of irregular little humps and twists as a convulsed snake which had tried and failed to straighten out. Barnes said disgustedly, "That's the worst job I ever did."

Wood said, "Look through it." Barnes looked and said, "Gosh!"

It was straight as the bore of a rifle—on the inside.

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CHAPTER ELEVEN

Wood Turns His Sabbaticals into Triennials, Stands Where Faraday Stood, and Is All Over the Map

THE average university professor is happy if he can take a full year's sabbatical once in every seven years. But nothing is ever "average" with Wood. He took his first sabbatical in 1910-11, another in 1913-14, went overseas again in a major's uniform in 1917, then again soon after the armistice, and has been making long visits to Europe in intervals ever since. His growing international fame, his many invitations to lecture before learned societies abroad, his researches with European colleagues, the funds derived from the Adams endowment for publication of his work by Columbia University, the appreciation of Johns Hopkins, which always gave him half pay during absence, all contributed toward making these triennials not only possible, but reasonable.

Wood began his first so-called sabbatical in the summer of 1910, after devising earlier in the year a new type of diffraction grating which he named the Echelette.[1]

[1] It was designed for work in the remote infrared region of the spectrum. These were coarse gratings having from 800 to 4,800 lines to the inch ruled with deep saw-tooth grooves in copper. Gratings for work with visible light have from 15,000 to 30,000 lines to the inch ruled on a harder metal, speculum, or aluminum on glass. He carried on a short research with Trowbridge at Princeton in which they examined the behavior and performance of the grating, incidentally resolving the carbon dioxide band at 4.3μ into a double band, which had never been done before. They did not realize the importance

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He went first to London, where he delivered the Traill Taylor Memorial Lecture, an annual function of the Royal Photographic Society, and the initial "Thomas Young Oration," a similar affair just started by the Optical Society. He then joined his family in Paris. Elizabeth, now aged twelve, was placed in school there, and Robert, Junior, aged sixteen, at school in Geneva. Margaret, now a tall young lady of seventeen, accompanied her parents to Berlin.

In Berlin, the Woods found a pension facing the Tiergarten, near the school where Margaret chose to study art. Wood's amateur talents in this direction had been increased in their transference to the daughter, who later made a name for herself as an outstanding portrait painter.

The family was now joined by their old friends, the Trowbridges. With Trowbridge, Wood attended the celebration of the hundredth anniversary of the founding of the University of Berlin. They went as official delegates from Johns Hopkins and Princeton. The ceremonies were elaborate. Kaiser Wilhelm was there in gorgeous uniform. With him was the pretty crown princess with whom, according to Trowbridge, the irrepressible Wood (delegate from Johns Hopkins!) carried on a mild flirtation during the tedious ceremony.

Soon Wood was deep in research with Professor Rubens, who fifteen years before had encouraged him to change from chemistry to physics. The research with Rubens was on a new method they had developed for isolating and measuring the longest heat waves ever discovered. It was at the time when efforts were being made all over the world to fill the gap in

of this discovery at the time, and their paper was overlooked by Bjerrum, whose theory of molecular band spectra published in 1912 predicted a double band in the infrared as a result of a vibration in the molecule combined with its rotation. The double band was rediscovered in 1913 by Eva von Bahr, to whom credit has always been given for proving experimentally the theory of Bjerrum. The band had been pictured and described in the *Philosophical Magazine* three years before. Bjerrum's oversight was probably due to the title of the paper: "Note on Infra-red Investigations with Echelette Gratings."

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the spectral region between the longest infrared heat waves and the shortest electric or radio waves, for Maxwell's theory showed that light and electromagnetic waves differed only in length. The method which they discovered was called focal isolation and depended on the odd circumstance that crystalline quartz was exceedingly transparent to a group of waves far longer than any discovered in the infrared, while having at the same time an index of refraction much higher than for visible light, in other words "anomalous dispersion." They succeeded in isolating heat waves of over 0.1 of a millimeter,[2] the longest observed at that time.

Wood announced one day at lunch at the pension in which they were living, "We've found and measured the longest heat waves ever observed."

"How long were they?" asked his daughter Margaret.

"One tenth of a millimeter," announced Wood triumphantly.

"I don't call *that* very long," commented Margaret in a bored tone.

These invisible rays from the lamp had very curious properties, they found. A quartz plate so heavily smoked that the sun was invisible through it was perfectly transparent to them; and the same was true for a plate covered with a thick opaque layer of finely divided metallic copper, while a plate of hard rubber half a millimeter thick transmitted about 40 per cent.

Plates of rock salt, which are extremely transparent to the greater part of the infrared spectrum previously studied, were absolutely opaque to these rays.

It was a matter of considerable theoretical interest to find out whether an extremely thin plate of salt would transmit anything.

"We need a plate half a millimeter thick, if possible," said Rubens. "I shall order one from Steinheil [an optician and

[2] Later on, using the same apparatus but employing a mercury arc lamp instead of the Welsbach, Rubens and Von Bayer isolated a radiation having a wave length of 0.3 of a millimeter.

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lens-maker]. He can do it, I think, and we shall have it in two weeks."

"Why not make it ourselves?" said Wood.

"Can you, then, grind and polish a rock-salt plate?" inquired Rubens in surprise.

"I don't know," said Wood. "I think so."

He took the thinnest salt plate they had and ground it against a sheet of ground glass, slightly moistened with water, until it was about half a millimeter thick. This was all that was required, but the thinner the better, so Wood thought he'd see if he could go further. Attaching the plate to a match stick with sealing wax, he dipped it into a glass of warm water and dried it quickly with absorbent cotton. It was slightly thinner, and the "ground" surface had become polished and transparent. He dipped it in the water and looked at it again (as did the Hatter at the mad tea party). It was still thinner. One more dip proved to be the limit, as the plate showed evidences of going to pieces at one corner.

Rubens breezed into the room, having finished his lecture.

"Well," he said, "and can you make us the salt plate?"

"Yes," said Wood. "It's finished."

"And how thick is it?"

"One *tenth* of a millimeter," said Wood, who had just finished measuring it.

Early in December the Woods were invited to attend the festivities in Stockholm in connection with the awarding of the Nobel prizes, and Wood was invited to deliver a lecture there on his recent researches in optics.

While carrying on the research with Rubens, he had also been investigating the optical properties of iodine. This had led to a capital discovery which was the small but solid foundation upon which he built later on one of his most important and elaborate series of discoveries, described in numerous papers under the general title of "Resonance Spectra of Iodine," investigations that occupied him for several succeeding years

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and eventually, when theory caught up with experiment, were of considerable importance in unraveling the mystery of band spectra. The discovery came about in this way: having been struck, in some of his earlier work, by the similarity of the absorption spectra of sodium and iodine vapors and having prepared some glass bulbs containing iodine vapor for the purpose of studying its fluorescence and passing through one of the rooms in which a quartz mercury arc lamp of great intensity was burning, it occurred to him that possibly the iodine vapor might yield resonance spectra similar to those which he had observed and studied under such difficulties in the case of sodium. He borrowed a small hand spectroscope, set up a large lens, and formed an image of the arc on one of his bulbs. Splendid! A bright cone of fluorescent light inside of the bulb. Pointing the spectroscope at the bulb he observed a resonance spectrum far simpler and more clearly cut than any he had found with sodium, a series of bright lines, spaced with the precision of the graduations on a foot rule, extending from the green line of mercury up through the yellow-orange to the extreme red. This observation was made only a few days before his invitation to Stockholm, so he had a very young "baby" to show at his lecture.

What impressed Wood most on arrival in Stockholm was that it offered no facilities for *taking* a bath, although there were plenty of places where one could be *given* a bath. You were placed stark naked on an ironing board and scrubbed with excelsior, like a puppy, by a muscular Swedish woman. The Woods were entertained at dinner by the American Ambassador and his wife, who told Gertrude they had had a bathtub installed in their house, but found that the plumber had put the valves that controlled the hot and cold water flow on the other side of the room from the tub. When they protested that they would have to get out of the tub every time they wanted to change or adjust the temperature, they were told they "could ring for the maid"!

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At the huge banquet which followed the handing out of the Nobel prizes, Gertrude was seated at the head table next to Emmanuel Nobel, a nephew of the inventor of dynamite who had founded the prizes. He told her he was just back from St. Petersburg and had brought with him an enormous earthen crock of the finest caviar, a gift from the Czar to the King. "All I could take back as a gift to the Czar," he said, "would be a box of dynamite—and that, I'm afraid, wouldn't be very acceptable."

When the day came for his lecture, Wood performed a number of what Professor Lorentz, the famous Dutch physicist, had once designated "his beautiful and convincing experiments on the blackboard," making pictures for his audience of everything he was talking about. It diverted them, he said, and kept them from going to sleep. They must have been well diverted, for the Woods continued to be showered with invitations.

A luncheon was given them by Professor Mittag-Loeffler at his beautiful country home. He was the Chairman of the Nobel Committee, was in Berlin in the autumn, and had extended the invitation to the Woods to come to Stockholm. He was proud of his library, said to be the finest collection of books on mathematics in the world. It was housed in a huge tower, ascended by a great spiral stairway.

Mrs. Wood tells a story about the formal reception which formed a part of the program. The Crown Princess Maud was receiving in a small room which opened off the large hall, and the chamberlain told the Woods they would be taken in soon and presented. Wood was meanwhile introduced to the first lady in waiting, a beautiful and vivacious young Englishwoman, and Mrs. Wood says the chamberlain experienced great difficulty in prying Wood loose from her when the time came for presentation to the Crown Princess.

Wood had an absurd run-in with the German customs. Going to Stockholm he had taken along a suitcase crammed with

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glass bulbs, lenses, prisms, rubber tubes, and other odds and ends and gadgets for the lecture. When, on the return trip, they reached the German frontier at Malmö and were lined up at the customs barrier, Wood had to open it.

"Ach! Was haben Sie hier?"

Wood explained it had all been made in Germany and was the property of the University of Berlin; that he had taken it to Stockholm for a lecture and was returning it to the University. "That makes no difference," said the guard. "You have duty to pay." Wood argued, but to no avail.

The customs officer emptied the case, putting all the glass together, prisms, lenses, and bulbs in one lot, brass gadgets in another lot, rubber tubes in another; and then weighed each lot, noting the weights on a card. He then spent five or ten minutes looking up the rate on glass, brass, and rubber articles, and the quartz mercury lamp, and since he couldn't properly classify this, about another quarter of an hour slipped by. Finally he added up the column, then added it again to make sure that no mistake had been made, and said triumphantly, *"Na— Ja, ja, Sie haben was zu bezahlen! Sie bezahlen zwei Mark fünf und vierzig Pfennig."* The English equivalent would be roughly, "You bet your life you have duty to pay! You pay two marks and forty-five pfennigs." Sixty-two cents for three-quarters of an hour of an official's misspent time.

Back in Berlin, Wood continued his research, in collaboration with Professor James Franck, subsequently a Nobel prize winner. They had previously worked together on the reduction of intensity of the iodine vapor in fluorescence caused by admixtures of chemically inert gases, and they now made the remarkable discovery that when helium gas was mixed with the iodine vapor, the spectrum of widely separated lines emitted by the vapor when illuminated by the green light of the mercury arc, which Wood had discovered a few weeks before, was transformed into a band spectrum of many hundreds of lines. The theoretical physicists, who occupied themselves

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with the problems connected with the radiation of atoms and molecules, were unable to find any plausible explanation for any of these effects, and it was not until many years later that they were completely understood, as will appear later. The research with Franck was completed in a couple of weeks, and the paper sent off to the English and German journals of physics.

The Woods next gathered up the family and went to St.-Moritz for Christmas and winter sports. Here Wood got on real skis for the first time, and would have nothing to do with sleds or skates. An ice rink, made by flooding a half-acre rectangle behind the hotel, had no attraction for him. He refused to take lessons, but watched the experts, and bought a book on *Skiing without Tears* or something of that sort, and at the end of the week could execute in low gear what he optimistically called a Telemark. At the end of the second week, high speed, without sharp turns or sudden stops, did not trouble him, and he had a great thrill, he says, "when, after a climb of over two hours up the mountain behind the village, with spots that called for 'herring-boning,' I came down against the wind and sun in one long, wild rush, immunized against terror by excitement, and like Mark Twain in his 'Lost on the Mountain,' finally found myself in the back yard of the hotel."

From St.-Moritz the Woods went to Paris, and Wood started an investigation with an Englishman, Hemsalech, in the laboratory of the Sorbonne, on a new radiant emission from the spark which he had discovered in Baltimore. He also carried out some more accurate measurements of the iodine emission lines than he had been able to make in Berlin.

In the early spring Wood and his wife made a trip to Sicily, and it was here, when the almond blossoms were pinkest, that he made his best and most striking infrared photographs, which were exhibited at the annual exhibition of the Royal Photographic Society a little later and published in the *Illustrated London News*. They stayed at the Hotel Politi in

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Syracuse, perched on the brink of the deep quarries of Latomia, in which the hundreds of Athenian prisoners were confined and starved to death after the defeat of Alcibiades by the Syracusians in 414 B.C. In these quarries Wood made some striking infrared photographs.

I was intrigued greatly (says Wood) by seeing what purported to be the tomb of Archimedes. Reading in boyhood in my father's old copy of Arnott's physics about the screw pump for raising water, invented by Ar-*kimmy*-des (as I always pronounced it), I had constructed one by winding a long piece of lead pipe in a spiral around an old rolling pin from the kitchen closet. History says Archimedes set little value on his mechanical inventions, regarding them as beneath the dignity of pure science, but they were the things that appealed to the popular imagination and have kept his name alive after a lapse of over two thousand years—rather than his contributions to geometry and mathematics.

Wood also is annoyed sometimes when his electrical thaw, his fish-eye views, his color photography process, and other mechanical inventions are stressed in the newspapers as his major achievements.

From Sicily they went to London early in May, 1911, where Wood had been invited to give one of the "Friday evening discourses" at the Royal Institution, founded in 1799 by Count Rumford.

The Friday evening discourses dated back to the time of Sir Humphry Davy and Michael Faraday (whose experiments with electric currents laid the foundations for modern electrical engineering). They were of a semipopular nature, but were full-dress affairs, attended almost exclusively by prominent figures in scientific fields accompanied by their ladies. The lecture hall and its horseshoe-shaped lecture table were the same as they had been when Blaikley did his admir-

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able painting showing Faraday behind the table on which his crude little coils and magnets are displayed, delivering a Friday evening lecture, on December 27, 1855. Wood had often seen the picture, and as a young instructor at Madison had possibly dreamed of one day standing behind this same lecture table, covered with his fluorescent tubes and bulbs, his ultraviolet lamps, electric sparks, and other scientific paraphernalia. Now his dream was coming true.

After the audience is seated (says Wood) there comes a hush in the conversation, and the lecturer and his family, if present, are ushered into the room through a door, previously closed and guarded, behind and a little to one side of the lecture table.

His Grace, the Duke of Northumberland, not being available at the time, Gertrude entered the hall on the arm of the Right Honorable Earl Cathcart, Vice-President, followed by my daughter Margaret, on the arm of diminutive Sir William Crookes, who came nearly up to her shoulder and whose long white mustache, waxed at the ends into two sharp spikes, fascinated her. I brought up the rear. There was a brief introduction and at last I was standing behind the famous lecture table, giving my talk on the recent experiments I had made with invisible light. . . .

The morning after the lecture I was back at the rooms of the Institution, removing my apparatus and putting away in the glass cases such things as I had borrowed. Spying the largest Nicol polarizing prisms that I had ever seen, I asked Sir James Dewar, the director, if I could use them for a study of the polarization of the lines of my newly discovered resonance spectrum of iodine. It was of immense importance to discover if, when the fluorescence spectrum was excited by polarized light of a single color, such as the green line of the mercury arc, any or all of the eighteen lines of the fluorescent spectrum were also polarized. Dewar gave me a nice room to work in

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and everything that I required. It was going to be a tough job, needing a huge amount of polarized light, large mirrors, and lenses for concentrating it on the bulb containing the iodine vapor, and the big Nicol prisms for polarizing the light. Bulbs had disadvantages, and I adopted a long glass tube of good size with a bulb blown on one end and the other end drawn down like a cow's horn, bent off to one side and painted black. This served as a dead black background against which the fluorescence could be viewed through the bulb without disturbing reflections from the glass wall. I employed two very powerful quartz mercury arcs, one above and the other to one side of the tube, a huge concave mirror behind each lamp, and two large condensing lenses between the lamps and the tube. The research was completed in a week; all of the lines were found to be strongly polarized and there were excellent photographs showing the dark bands, which indicated polarization, cutting across all of the lines. A twelve-page paper, illustrated with photographs, appeared in the *Philosophical Magazine* shortly afterwards. This was the fastest work that I had ever done, which was a piece of good luck, for on the day on which I had written finis to it, Dewar strolled in with his hands behind his back under the tails of his frock coat and told me gruffly, as was his habit sometimes, that I'd have to vacate my room, since Marconi was giving the next Friday evening discourse and would need it for setting up and trying out his experiments. "I'm finished," I said, "and thank you very much."

It was advertised that at Marconi's lecture the audience would be able to listen to transatlantic signals coming from Glace Bay, Nova Scotia. This was at a time when some still doubted such a feat was possible.

Kites would be flown from the roof carrying the antenna, and the audience would be able to hear signals by a system of telephones distributed over the auditorium. Days before the lecture, the historic halls of the Institution were invaded by

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workmen moving in Marconi's apparatus. They took down the iron balustrade of the marble stairway leading to the second story, which interfered with the hoisting of some of the larger and heavier pieces of electrical equipment to the lecture room. The entrance hall was cluttered with packing boxes and excelsior for three days, and gradually there was assembled, behind the semicircular lecture table on which Faraday had set up his little coils and magnets, such a display of impressive modern electrical appliances as one seldom sees outside a World's Fair. A great marble switchboard with voltmeters, ammeters, rheostats, inductances, etc., etc.; several mysterious-looking polished mahogany boxes, with shining brass knobs and bars; and many other things in between these. During the afternoon preceding the lecture Marconi's two young assistants were on the roof of the Institution, raising the tandem of great kites and tuning the receiving instruments.

This interested me enormously, as I had been playing with kites at East Hampton, and I injected myself into the party, asking questions, making suggestions, getting in their way, and making other equally ineffectual efforts to help.

Marconi read his lecture from manuscript, his elbow on the reading desk and his forehead resting on his hand. He appeared to be the least interested person in the auditorium in what he had to say, and there were no experiments. Except that towards the end of his reading he said, "I have installed the apparatus here with which the signals are transmitted and you will hear the sound of the spark discharge in this box when I close the switch." He opened and closed it several times and we heard "Buz-buz-buz, Buzzzz-buzzzz-buzzzz, buz-buz-buz" (S O S).

About ten minutes before the end of the hour I noticed that his assistants were getting nervous. They were "off stage," and one of them kept disappearing every few minutes, then reappearing for a hurried whispered conversation. I tiptoed over to find out what was wrong. The transatlantic signals were

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coming in all right, but the wind was dropping and the kites were coming down.

"Tell Marconi," I whispered. "Let the audience hear them while they can and then finish the lecture."

They shook their heads. "Impossible," one whispered. "They are to come at the end. He would be furious if we interrupted him."

"Let me do it then," I said. But they would have none of it.

The lecture went on monotonously, and came to an end with the words: "We shall now listen to the signals coming across the Atlantic." He turned to his assistants who were standing at the side of the auditorium. They shook their heads, sadly, and one said, "The kites are down."

Marconi turned to the audience and explained that the failure of the wind had made the demonstration impossible. To me it sounded as if he were slightly pleased to be saved the trouble.

Walking out with Lord Rayleigh after the lecture, I said, "What did you think of it?"

"Well," he replied, "I feel disposed to think that if you or I had required something for a lecture that would make a buzz-buzz we could have accomplished it with simpler apparatus—and we'd have had the buzz-buzz."

The Woods now picked up Elizabeth and Robert, Jr., and sailed for home on the maiden trip of the *Olympic,* then the largest passenger steamer afloat.

After returning to America in 1911, and while continuing, of course, in his post at Johns Hopkins, Wood started a series of experiments with Professor Pickering of the Harvard Observatory on a new method of determining velocity of stars by photographing their spectra with an objective prism. These were very dramatic and involved the photography of entire groups of stars through a filter consisting of a glass cell filled with liquid—a solution of a chemical with the beautiful name

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of neodymium. This gave an additional absorption line in the spectrum of each star, from which calculations could be made of stellar velocities as stars approached or receded from the earth.

This was one of Wood's great contributions to astrophysics, a subject in which he has figured prominently ever since. The Wood-Pickering procedure continues to be used as one of the standard methods of measuring stellar velocity—though Wood today has a new method brewing which Harlow Shapley and other prominent astronomers believe may supersede all previous systems.

In the summer of 1911, Wood purchased and mounted at East Hampton a parabolic mirror of sixteen-inch aperture and twenty-six-foot focus, which he had arranged in conjunction with a large coelostat lent by the Naval Observatory. The coelostat mirror, turned by clockwork, followed the moon and kept the reflected beam horizontal and directed against the sixteen-inch concave mirror, which in turn formed an image of the moon at its focus near the coelostat where the plateholder and ultraviolet filter were mounted. Young Professor Masamichi Kimura, of Tokyo, who ranks today among Japan's greatest living scientists, had come over to study and work with Wood on sodium vapor, and was invited to East Hampton to help with the moon photography.

During their work a curious episode occurred. Kimura had been a welcome and popular house guest for a week end, and later was residing in a near-by hotel while they continued their summer experiments. One evening they'd been planning to photograph the moon with ultraviolet light. They had set up the telescope and mirrors in the late afternoon in a field clear of buildings, out beyond the barn, and Wood said, "Come over at eight o'clock."

The sky was clear, but between six and seven a heavy pea-soup fog rolled in from the ocean. It was summertime, but the fog was cold as well as thick. The Woods, who had been din-

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ing early, saved after-dinner coffee for Kimura and expected him to appear at the house any minute. He did not appear. About nine o'clock the fog began to roll away, and the sky cleared. A blanket of it, however, as it sometimes does toward Montauk Point, lay thick, waist-deep on the ground. Wood waded through it toward the telescope, planning to do the photography alone. As he approached the looming shelters that covered the mirrors, he saw another dark object embedded in the fog. It was the head and shoulders of the Japanese, sphinxlike in the clear, with the rest of him up to his elbows in the murk.

"Gosh," said Wood, "how long have you been here?"

Kimura took out his watch, consulted it in the moonlight, and said, "Hoh, have been here one hour and twenty-two minutes."

Wood doesn't guess at the answer. Kimura was an extremely intelligent and popular fellow, and knew from experience that he was always welcome at the fireside.

Not much came of these lunar experiments (says Wood), chiefly because of climatic conditions. Dew formed on the mirrors, the clock did not drive very steadily, and there were innumerable mosquitoes, who came from all directions to see what was going on. So later in the autumn through the courtesy of Professor H. N. Russell of Princeton University, I was given an opportunity of mounting my sixteen-inch mirror at the Princeton Observatory. Professor Harlow Shapley, now director of the Harvard Observatory, was then a fellow in astronomy at Princeton, and he assisted me in handling the telescope and making the exposures.

We made photographs of the full moon by orange, violet, and ultraviolet rays, the latter bringing out the dark deposit bordering the lunar crater Aristarchus with great distinctness, while the orange-ray picture showed no trace of it. Experiments showed that when a gray volcanic rock was treated at

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INFRARED LANDSCAPE: A 1911 photograph made by Wood of a summer landscape in Sicily—the earliest landscape photograph with infrared light ever made. Wood also pioneered in ultraviolet-light photography.

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PEGOUD UPSIDE DOWN: Wood pirouettes in the snows of St.-Moritz, in the costume he designed that won first prize at the fancy dress ball.

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one spot by blowing a jet of sulphur vapor against it, a thin deposit of sulphur crystals was formed which was invisible to the eye but came out black in a photograph made with ultraviolet rays. It therefore seemed probable that an extensive deposit of sulphur had been found on the moon's surface by the new photographic technique.

The plates obtained through the ray filters could be studied to advantage by the methods employed in the three-color process of color photography. The negative taken through the ultraviolet screen was printed on a gelatin film and stained blue, the violet and orange pictures being rendered in red and yellow respectively. The three films when superposed resulted in a very fine color photograph which brought out the differences in the reflecting power of the different dark areas on the moon in a very striking manner. The prevailing tone of the darker portions of the lunar surface was olive green, but certain spots came out with an orange tone and others with a decided purple color. The dark spot near Aristarchus came out deep blue, as was to be expected.

In 1911 Wood also continued his researches with mercury vapor and detected resonance radiation in the ultraviolet region, analogous to the sodium vapor resonance at the yellow lines. The thing of greatest interest was the invention of what he termed a resonance lamp.

A thin-walled bulb of fused quartz was blown, a drop of mercury placed in it, the air pumped out, and the bulb sealed. The mercury vapor in this vacuum bulb had sufficient density at room temperature to emit resonance radiation when illuminated by the light of a quartz mercury arc, operated with weak current at low temperature. The radiation was powerful enough to make a screen of barium platinocyanide glow with a yellow light, and if a drop of mercury was supported on a slightly warmed bit of glass between the screen and the resonance lamp, the vapor rising from the drop showed as a waving,

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fluttering column of black smoke on the yellow background. This made it possible to design an optical apparatus that would show the slightest traces of mercury vapor in the air of the room, a matter of importance in power plants where the engines are driven by the vapor of mercury instead of by steam. The vapor is very poisonous, and a very small leak in the high-pressure boiler or engine might exist undetected until the men showed symptoms of mercurial poisoning, by which time permanent damage would have been done. Several years later the General Electric research laboratory asked Wood to design apparatus for this purpose. He went to Schenectady with drawings, but they decided not to use it, as their chemical staff had prepared a paper that would turn black when exposed to the vapor. After getting along with this for several years, they found, according to report, that the paper was sluggish in its action, and might not respond to a sudden leak before a dangerous dose of the poison had been inhaled. One of the young men in the laboratory was then given the problem of making an optical detector along the lines suggested by Wood. After he had worked a year without results, Wood was consulted by an older member of the staff. It turned out that all that had been done was to try to detect the absorption of the vapor by the light of a high-pressure, high-temperature quartz arc. Wood pointed out the foolishness of this attempt, since practically no light capable of being absorbed by traces of the vapor is emitted by such a lamp, for it is all absorbed by the cooler layer of vapor surrounding the arc proper in the tube of the lamp. They were instructed to use a resonance lamp, or an arc operated at very low temperature, and within a year the papers were full of the "electric nose" for smelling mercury vapor in the air, developed by engineers of the General Electric Company. It was identical with Wood's first suggestion, except that it was arranged to ring a bell, instead of showing the presence of the vapor by a difference of luminosity

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in the two halves of a circular phosphorescent screen, a mere matter of using a photoelectric cell and amplifiers.

In the early part of 1913, Wood was invited by Sir Oliver Lodge, chancellor of the University of Birmingham, England, to attend the annual meeting of the British Association in September—and to receive the honorary degree of Doctor of Laws from the university.

As they were planning to take a second sabbatical year abroad at about this time, Wood accepted the invitation and went on ahead to England, while the rest of the family proceeded to Paris.

Sir Oliver Lodge was president of the British Association that year, and the meeting was the largest since 1904. Among others who were to be presented with LL.D.'s at the same meeting were Professor H. A. Lorentz and Madame Curie. In presenting Wood for the LL.D., Sir Oliver characterized him as "one of the most brilliant and original experimental physicists in the world."

In his own address at the meeting, Wood described experiments with resonance spectra and amused the distinguished gathering with an account of his use of the family cat to clean the spectroscope. *Nature,* in reporting his speech, was even more glowing than Sir Oliver had been in his presentation. A little later Frederick Soddy, subsequently professor of inorganic chemistry at Oxford, referred to Wood in the same journal as "one of modern experimental research's greatest masters."

Wood still found time to enjoy himself. Before he left England, he went out to the great automobile race track at Brooklands for the races, where he also witnessed a stunt that set the aeronautical world agog. Pegoud, the French aviator, was to do his new and famous act in which he not only looped the loop "outside" as well as "inside," but actually flew upside down for a quarter of a mile. "It was a lovely autumn day," says Wood, "and the great stadium was packed. There came the hum of a motor high up in the air and we saw the

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tiny aeroplane with Pegoud's helmeted head showing above the cockpit. A loop, another and another, and then the plane flying on a horizontal path, upside down with Pegoud's inverted body hanging by the straps. The crowd of twenty thousand came to its feet with a gasp and a prolonged 'A-a-ah.' The plane dived again, turning over, and sailed along right side up with Pegoud now only a hundred feet above the ground waving to the cheering and shouting spectators."

Wood was tremendously pleased with the show, and later made amusing use of his impressions.

He joined his family in Paris, and they all spent the Christmas holidays again at St.-Moritz, stopping at the Kulm Hotel. Among the guests was a rich Rumanian, M. Stolojean, whose beautiful wife, Marna, was the daughter of Rumania's War Minister, M. Filipesco.

Before dinner every night, M. Stolojean gave a cocktail party for his own group and invited the Woods. They got along famously. Marna, Wood says, wore a new dress and a new jewel every evening, and her husband had a pocketful of gold pieces, one of which he always left on the table after signing the card. There was bobsledding by day and dancing at night. The climax was to be a costume ball at Christmas. At lunch on the day of the ball Margaret asked her father whether he was planning to go and what he would wear.

I'll let Wood tell the story, since it's one he likes to remember.

I replied to Margaret, "I'm not going to pay a hundred francs to rent a harlequin pajama, or three hundred francs to be an Indian prince for a night." But Margaret kept at me to go, and I finally said, "All right, I'll come. I'll come as Pegoud, upside down in an aeroplane."

"Oh, marvelous, but *how* will you do it?"

"Well," I said, "my head and shoulders will be in the pasteboard fuselage. Gnome motor and propeller in front, the wings

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supported by my extended arms, white gloves on my feet, and a huge Frenchman's head, helmeted and goggled, and with a thick beard, all securely fastened on upside down on my behind."

Gertrude said, "It won't be funny, it'll just look like you with a mask on your behind." But I saw the picture in my mind's eye, dashed down to the village, and bought yards of yellow cheesecloth, got an armful of thin bamboo sticks from my ski man and a lot of cardboard, and hurried back to the hotel. By forcing Gertrude, Margaret, and Elizabeth to sew vigorously all the afternoon, and gluing and painting cardboard myself, I had the whole contraption finished by six o'clock. It cost altogether less than three francs.

M. Stolojean came in to view it after the cocktails. He danced about in delight. "You shall have the first prize. Leave all to me," he said. "I will arrange all; the floor shall be cleared after the fourth dance, you are to stay in my room until the band strikes up the Marseillaise, I will have a claque by the door, and there will be shouts of *Il vient Pegoud! Vive Pegoud! Pegoud comes!* and you tear across the hall and dance a *pas seul!*"

"Great," I said. "I'll do stunts, spirals, sideslips, everything." We'd had some cocktails. "I'll do my celebrated whirling dervish act, in which I spin for over a minute and then walk a chalk line."

It came off exactly as planned, and there was tumultuous applause as I did a sideslip through the door, and shrieks of laughter as I turned and the face and beard came into view. With the band crashing the Marseillaise with an enthusiasm created by many gold pieces, and the huge waxed floor completely deserted, the walls packed with standing spectators, I did things I did not imagine possible in the way of stunts. That the illusion was fairly good, I found out the next morning when shown photographs, one of which appeared the next week in the London *Sketch*. Later I was able to dance with the

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ladies, for I had constructed the wings in such a way that I could wrap them around my partner, enveloping her in the manner of a bat doing a bunny hug with a white mouse. At the end of the party, the drum rolled for silence, and the master of ceremonies, a retired English colonel, arose to announce the prizes.

"This first prize, by unanimous vote of the committee," he roared, "goes to Pegoud." I folded my wings around my body, bowed, and was handed a white box, which when opened disclosed a full set of garnet sleeve links, studs, collar buttons, etc. Gertrude overheard in a group next morning, "Really, my dear Lady Mary, I don't see *why* they gave the prize to Pegoud, because after all it wasn't Pegoud *at all,* and besides it wasn't a pretty costume."

Wood never brags of his great scientific achievements, but is vain as a child concerning triumphs of that sort.

He returned, with his family, to Paris, finished up his research, and sailed for home in June, 1914.

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CHAPTER TWELVE

Wood as a Poet and Author—or the Splendors and Miseries of a Scientist Who Strayed into Popular Literary Fields

ONE DAY Wood met Oliver Herford in the Players Club, and Herford said, grinning, "Come along and have lunch and I'll promise not to autograph any more of your funny books."

Wood had turned aside from science, as Lewis Carroll did, to perpetuate "a revised manual of flornithology for beginners," entitled *How to Tell the Birds from the Flowers.* It had got off to a bad start in 1907—then suddenly was all over the place —and a lot of people later attributed it to Herford, saying that only Herford could have written it. Dr. Wood had written it for his own amusement, to spoof the public and as a book to end all books on botany written for children by the mushy male and female nature-fakers of the period. It was done with jingles, woodcuts of his own drawings, and appalling puns. It began by explaining how to tell the difference between the crow and the crocus, the catbird and the catnip, the clover and the plover, the quail and the kale, the roc and the shamrock—then invaded the piscatorial and animal kingdoms to treat of the ape and the grape, the pansy and chimpanzee, the puss and octo-pus, the cow and the cowry.

It had appeared under the imprint of Paul Elder & Co., and Elder hadn't succeeded in making it go. "None of the bookshops would stock it when approached by Elder's salesmen (if

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he had any)," says Wood. "Boston's largest bookshop reluctantly took six copies, on consignment. A few weeks later they ordered five hundred." It was super-nonsense and had begun to catch on by word of mouth. Then the Sunday supplements began splurging its cuckoo drawings—and all of a sudden it was going like wildfire.

Wood sent President Theodore Roosevelt an autographed copy of *Birds and Flowers* at a time when he was being violently attacked as a "nature-faker" by a certain Reverend Long. Wood wrote on his flyleaf, "I am venturing to send you a remark-proof copy of my current Nature book, which I trust will fill a Long-felt want." Roosevelt sent a cordial acknowledgment, and asked to see more of Wood's writings. So Wood sent him a copy of *Physical Optics!*

And who, wondered children and grownups, was this Robert Williams Wood? If they'd ever heard of a famous professor of physics by that name—which most of them hadn't—it didn't occur to them to connect the names. . . .

Wood is no shrinking violet, and one night the story that Herford had written it got in his hair. It was at a dinner party in Washington. Someone chanced to quote from the book, and the man sitting opposite said, "Oh, yes, that's from the *Birds and Flowers* thing by Herford."

Wood said, "I beg your pardon, but Herford didn't write it."

"Well, I happen to know he did," said the man a bit truculently. "You see, Oliver Herford happens to be a friend of mine."

"I can't help that," insisted Wood, "but I tell you he didn't write it."

"What makes you so sure he didn't?"

"Because I wrote it myself!" Wood exploded. "And then," says Wood, recalling the episode, "he *knew* I was lying."

How to Tell the Birds from the Flowers is now in its nineteenth edition and still going strong.

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The Crow.

The Crocus.

Some are unable, as you know,
To tell the Crocus from the Crow;
The reason why is just be-caws
They are not versed in Nature's laws.
The noisy cawing Crows all come,
Obedient to the Cro'custom,
A large Crow Caw-cus to convoke.
You never hear the Crocus croak!

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You might think this one alarming if successful excursion in the field of popular authorship would have been enough for any busy laboratory scientist—but not for Wood! He was infected. It's like malaria and danghi. The bug had bitten him, and by early 1914 he was being an author again in his misguided moments, with results which were equally extraordinary, in their different way . . . for the scandalous genealogical truth, stemming down from the Verne-Wells family tree, is that Wood was the American grandfather and Arthur Train the grandmother of the present flood of pseudo-scientific fiction which fills the pulp magazines and sometimes the slicks with interstellar catastrophes and journeys in moon rockets—and the comics with Flash Gordon and Buck Rogers.

Back in 1914 Arthur Train was spending the summer at East Hampton, and dropped in frequently to see Wood, in the barn laboratory. They were both Jules Verne addicts, and one day Wood said to him, "I've got a swell plot for a story." He sketched the outline of a tale in which, during the middle of a world war, messages come from a mysterious unknown wireless station warning the powers that unless they stop the war the sender, who signs himself "Pax," will shift the orientation of the earth's axis by the aid of his disintegrating ray and atomic power and cause a second Ice Age in which all northern Europe will be covered by glaciers and destroyed. Regarded as a harmless crank, "Pax" finally broadcasts a message that, to show his power, he will, on the twelfth of March at noon, lengthen the day by five minutes. The time arrives, and what happens is described by a common citizen sitting in Central Park contemplating the obelisk.

There is a godawful thundering rumble, the ground quivers, the obelisk crashes to earth, and the skyscrapers sway back and forth. Newspaper extras report terrific earthquakes all over the world, and next morning dispatches from the Greenwich and other observatories report that the stars are two and a half minutes late in crossing the meridian. Later dispatches state

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The Elk. The Whelk.

A roar of welkome through the welkin.
Is certain proof you'll find the Elk in;
But if you listen to the shell,
In which the Whelk is said to dwell,
And hear a roar, beyond a doubt
It indicates the Whelk is out.

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that the period of the earth's rotation has been increased by three minutes.

Then comes the episode of a "relay" gun that shells Paris from a distance of seventy miles. This was three years before the Big Bertha. Presently a "flying ring" driven by atomic power in rocket form roars over Europe, directing its rays against the ground, which is torn to bits. Crossing the Mediterranean, it causes a tidal wave that swamps everything in its path.

The mad pacifist genius is finally located in Labrador by Professor Benjamin Hooker, a young Harvard physicist (Wood himself, of course, romanticized), who discovers the secret of the disintegrating ray. Uranium ore was the key to it, which was curiously prophetic, in the best Jules Verne tradition, of the present experiments with neutron rays generating atomic power from uranium. Hooker is rescued and aided by a famous and daring young aviator named Burke, and together they bring about the destruction of the earth-destroying plot. If I recall correctly, "Pax" blew himself up by overloading his disintegrator.

"Arthur Train was enthusiastic," says Wood, "but we worried for days about the title. Then one morning I said to him, "I've got it! *The Man Who Rocked the Earth.*"

The story was written speedily in collaboration. Wood wrote the scientific and pseudoscientific passages and worked on the mechanical plot, while Train took care of the "literary" and human-interest elements. It ran serially in the *Saturday Evening Post,* and was published as a book by Doubleday, Page & Company in 1915. The title page acknowledges the joint authorship, but Wood was sore (and small blame to him) because they left his name off the gilt-lettered cover. He promptly complained, and Doubleday, Page made a handsome if hollow apology. They told the poor prof a pretty bedtime story. The omission was due, they wrote—and were so sorry—"to a clerical error"!

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Presently, nevertheless, and despite some bickering over the division of the spoils, Wood and Train went into a similar collaboration on a sequel entitled *The Moon-Maker,* which was published serially by *Cosmopolitan.* A comet collides with an asteroid, knocks the latter out of its orbit, and sends it hurtling through space, so that it is presently going to hit Texas and destroy the world. Now who can better save the world than the bright young physicist (romanticized as Hooker in the former book), with the help of the daring young flyer named Burke? For, you see, they had learned in the previous opus to operate the "flying ring" and shoot the works. The ring is a sort of superrocket propelled by atomatic energy and armed with rays which can explode the asteroid or knock it for a series of loops. They had everything it took —except a heroine. If this had been going to take place in interstellar space exclusively, they might not have needed a heroine, but since they were concerned with its occurring also in Hearst's *Cosmopolitan,* a heroine was essential. So Wood and Train invented a beautiful young lady named Rhoda Gibbs. She begins honestly enough as a precocious young mathematical assistant, but ends up as a stowaway "staff photographer" when the "flying ring" takes off—and to thicken the soup, Professor Hooker has fallen in love with her!

Hooker, Burke, another scientific guy thrown in for good measure, and the beautiful Rhoda presently take off and land to refuel on the moon, where she makes wonderful moonlandscape pictures. Later they meet and combat the asteroid. They partially explode it and drive it into an orbit in which it peacefully revolves around the earth—preventing our destruction and giving us a nice additional new moon!

It was in the bag, heroine, climax, check coming up from *Cosmopolitan,* and everything, and you might suppose that at this point our scientist astray as an author might have gone back into the Johns Hopkins laboratories and sat down. But not Wood!

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While Train was polishing off Rhoda, Dr. Wood conceived the additional fantastic idea of illustrating this modern Jules Verne romance by concocting an actual set of photographs, as supposedly taken by the beautiful heroine. Train and the staff of *Cosmopolitan* were entranced by the idea, so Wood went to work in his East Hampton barn. He made plasticine models, did tricks with charcoal drawings and light, stole a croquet ball from the family set and painted it to represent the receding earth as seen through the camera lens of the departing Rhoda. He photographed it, as Rhoda would have had to do, through an infrared screen on a panchromatic plate. He modeled and photographed lunar landscapes, illuminated by oblique sunlight, showing the circular craters and volcanic peaks with their long shadows. When he wanted to show Burke or Rhoda walking in the foreground, in helmet, with oxygen tank, etc., he did it by using pictures of deep-sea divers in armor, cut from magazines. One really beautiful picture shows the "ring" high in the air with its blazing rocket tail over the lunar landscape. The sky in these photographs is inky black and studded with stars. The moon has no atmosphere and therefore no blue sky. He did ingenious photographs of the attack and partial destruction of the asteroid by the disintegrating ray, as if made through the window of the "flying ring," as well as photographs of the collision of the comet and the asteroid taken through the great telescope on Mount Wilson, perfectly beautiful and scientifically accurate fakes.

Alas and alack, however, when the finished photos were shown to the editor in chief of *Cosmopolitan,* he threw up his hands in dismay and said, "I suppose they're wonderful in their way—but they're too wonderful—in their way, which is not our way. They'd make *Cosmopolitan* look like a copy of *Popular Mechanics!*"

Dr. Wood wants me not only to admire but to *sympathize* with his struggles, triumphs, and frustrations in the field of popular authorship. I can admire him and even envy him but

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I can't see that he needs sympathy. *Birds and Flowers* now answers itself. Everybody knows he wrote it, and it's doing fine. His name didn't appear in gilt letters on the cover of *The Man Who Rocked the Earth*. He got only $300 for his part in its serialization, and *Cosmopolitan* refused to use his photos in the sequel. . . . So what?

I honestly don't believe it has ever occurred to the man that he was not only the creative originator, but the (thinly disguised) hero of both latter books, and that if they chance to survive the welter of interstellar pulp, he'll cash in posthumously on his prophecies (as Jules Verne did long after he was dead), despite the fact that his name didn't appear in gilt letters, through a "clerical error"!

It's sad enough when we read that treatment of this sort turned Samuel Johnson and Oliver Goldsmith testy. When it happens to Wood, who innocently "strayed" into poetic and literary fields, I suppose I should break down and cry—but I don't. I'll be damned if I'll sympathize with any amateur author whose poetry ran into nineteen editions and whose pseudoscientific sensations were published in the biggest popular magazines in America.

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CHAPTER THIRTEEN

Wood Tunes in on the World War—Invents New Methods of Warfare, Including Trained Seals to Chase Submarines

While Wood was in Europe, in the autumn of 1913, he was invited to become a member of the Solvay Conference of the International Physical Institute which was meeting in Brussels. There were present about thirty eminent scientists, among them Einstein, Sir James Jeans, Lindeman, Rutherford, Rubens, Langevin—and Madame Curie. Madame Curie was the only woman, and at the opening of the congress she requested that the others refrain from smoking, as she disliked the smell of tobacco. Since the Institute had provided for each member a box of Havana cigars, her request was unpopular. At the second session, Wood (having meanwhile plotted with Professor Jeans) took out his pipe and lit it. Jeans followed suit, then one by one the other members helped themselves to cigars. Wood says Madame Curie rose, gathered her papers, and departed.

At about this time Wood bought by chance a little headphone radio—or "wireless receiving set" as it was called in those days. The day when they'd bring voices and music and be a fixture in every home was still in the far distant future. There was nothing to pick up from the Eiffel Tower station, or from anywhere, except Morse code. Nobody had receiving sets except cranks and scientists. How Wood acquired one,

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learned code, kept the gadget, brought it home to America, and "tuned in" privately on the World War before either the public or the newspapers got it can best be told in his own words.

We lived in an apartment on the Avenue Charles Floquet almost in the shadow of the Eiffel Tower. One day on the way to the Sorbonne I had passed an electric shop and saw a little galena headphone radio set in the window. There was a sign suggesting that you could use this set to listen to the Eiffel Tower radio station. So I thought it might be fun to learn code and I bought it.

An invalid friend of mine, a brother of S. S. McClure, who also lived at 14 Avenue Charles Floquet, worked with me, and in time we both learned to read Morse code. I bought him a set. We used to practice sending and receiving together. Mrs. McClure said she thought it saved his life. Signals came in from the Eiffel Tower with such strength that you could often see a spark between the cat whisker and the galena crystal on my receiving set.

When I got home—that must have been about the end of June, 1914—I decided I might as well keep on with code practice if I didn't want to forget it, and I installed a set at East Hampton, just about the same as the one I had in Paris, but with 150-foot antennas. Messages began coming in with good strength from Wellfleet on Cape Cod and from the German Telefunken station at Sayville, Long Island.

A few days before the outbreak of war, early in August, I was recording letters one at a time, as they came in, without realizing what it was all about, as is usual with novices. The message stopped suddenly, and I found I had written, "To all German ships at sea. England has declared war on Germany. Proceed at once to the nearest German port. On no account touch at French or English ports." And then the Telefunken call letter signing off. This message was repeated at intervals

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during the day and night. I wondered why these messages were always in English. After war was declared, messages continued to come in from Telefunken, usually in English, addressed to the German cruisers *Dresden* and *Karlsruhe,* and this kept up for three or four weeks after the war had begun. We wondered then why the government permitted the sending of these messages from an American station. Later on the government put a stop to it.

There were a lot of messages in a strange code coming from Telefunken, with words like "Cuckoo Buffano" and "Ciro Teliko." These words came in so frequently that I still remember them.

War news used to come in from Wellfleet and Telefunken (until it was closed down), and we got the latest news at East Hampton long before the newspapers reached us. People got into the habit of calling me up at all hours of the day and night—even drunks on the way home from dances would drive into our yard and wake me up shouting, "Hey, Prof, what's the latest from Europe?"

Before the war was a week old Wood had written a letter to Lord Rayleigh, suggesting a method of destroying Zeppelins, on which public attention was focused at the moment. The attacking plane was to fly across the path of the Zeppelin a little ahead of her and drop small flaming steel darts, making a barrage of fire through which the airship would have to fly. The darts were to be threaded on a metal rod, which was to be drawn back by a mechanism that would release them at such intervals that the distance between them would be less than the width of the Zeppelin. This would make a hit certain and a single hit would mean the destruction of the airship by fire. This was essentially the mechanism now in use and referred to as "a stick of bombs."

Early in November, 1914, he sent to the French, through Ambassador Jusserand, the suggestion that brombenzyl vapor

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or some similar compound be released in enormous quantities over twenty or more kilometers of the Western Front, at a time when the meteorological department could guarantee a west wind for several hours. The slightest whiff of this vapor causes a smarting pain in the eyes and a copious flow of tears. It is impossible to keep the eyes open, and, he pointed out, all that remained would be to advance and capture the weeping Germans, for a man who can't see, can't shoot. He pointed out that it would not violate the Hague convention, as no permanent injury resulted. This was six months before the Germans started gas warfare on too small a scale with chlorine, and gas masks were speedily developed. Tear gas came into general use later on.

Wood says the idea occurred to him suddenly as he was walking from a meeting of the National Academy with Professor Pupin and Dr. Welch, both of whom laughed at the idea and said a gas would soon be dissipated in the air. Wood replied that the odor of a fish-fertilizer factory fifteen miles from East Hampton was suffocating when the wind was right.

Later in the war, when he was in France, he discussed the question with the French gas people and reminded them that he had made this suggestion in 1914. They agreed with him that had they tried this on a twenty-five-kilometer front they probably would have broken through.

Shortly after America's entry into the war, a meeting of the Naval Consulting Board was held in New York at the request of Admiral Sims. It consisted of a group of civilian scientists, engineers, and also naval officers, who were expected to think up useful ideas for the Navy. Sims was about to sail for England to discuss antisubmarine activities with the British Admiralty and wanted to arm himself with the latest suggestions. Dr. Wood, though not a member of the board, had been invited to participate.

During the exchange of ideas, Dr. Wood suggested that experiments be made with what are now called "blisters." His

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idea was to have an outer shell of thin steel subdivided into a number of air-filled chambers, welded to the hull on the outside of warships, below the water line. A torpedo would explode on contact with the outer shell and the gases would expand into the air space and lose most of their destructive force. He said the idea could be tried at small cost on some condemned hull, substituting a bomb for the torpedo. Hudson Maxim, the explosive expert of the board, leaped to his feet and shouted, "Professor Wood is all wrong. The compartments should be filled with *water* instead of air." This was perfect nonsense, and there were cries of "No, no."

Sims rapped on the desk and said that further discussion would be a waste of time, as the British Admiralty had informed him no antitorpedo defense that involved the building of any structure whatsoever on the outside of the hull would be considered.

The English battleships and cruisers were equipped with "blisters" in the latter part of the war, and they are shown in many photographs of ships engaged in the present war. The principle of antitorpedo air pockets is now standard practice in naval construction, but they are incorporated within the hull. It seems strange that Sims knew nothing about them at the time of the meeting in New York, if they were already in use in the British Navy.

It was at this same meeting that Wood amazed them all—and shocked most of them purple—by suggesting that it might be a bright idea to train seals to chase submarines! They laughed, and some member tried to start a new topic. But Wood stood up and claimed the floor. He was a great scientist, and so they listened to him—and so help me God, the British Admiralty later tried it!

Wood began by pointing out that seals could be taught almost anything that dogs could. A collar with a steel wire attached to a large hollow ball of rubber painted scarlet and dragged along on the surface would enable the sub-chaser to

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follow the seal! A. G. Webster, professor of physics at Clark University, protested against wasting the board's time with such a silly suggestion, and another member said you couldn't train an animal to do anything it had no natural instinct for. Wood countered by asking, "How about fox hounds following a bag of anise seed?" and suggested that it would do no harm to consult a professional seal-trainer, who would be the one best qualified to decide whether the suggestion was worth trying.

Sims took the idea over to London, and within a month the Admiralty was conducting experiments with seals, on a lake in Wales, admitting subsequently that the idea had come through the United States naval attaché in London. They found that seals could be trained to hunt out and follow the sound of a submarine's propeller, and perhaps the odors from the oil and exhausts. The experiments were commenced with an electrical "buzzer," and the hungry seal was rewarded with a fresh fish as soon as he located or followed it. In experiments with their own submarines, they had what Dr. Wood characterized as "considerable success."

The "water bloodhounds" never trailed or caught any German U-boats, however, and as a would-be honest biographer I am compelled to say that the "considerable success" attributed by Dr. Wood to his trained seals was not a determinate factor in marine warfare. The seals had been muzzled to discourage independent fishing expeditions of their own, but one of the difficulties encountered was that they had a tendency to run off after schools of herring anyway—just as the bloodhound abandons Eliza or a convict to go off chasing rabbits. Other difficulties were that the seals not infrequently followed wrong ships, and that the floats attached to their collars could not be made large enough to be clearly visible at great distances or in fogs. The seals did learn to trail oil, and learned for that matter to trail the sound of screw propellers, and therefore proved Dr. Wood's contention—but the whole business leaves

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me with the conviction that the idea was even more "screwy" than the sterns of the U-boats. One thing of importance did result from these fantastic experiments. They proved that the seals could hear perfectly well when swimming at full speed under water, and this discovery was responsible for an improvement in the performance of the hydrophones or "listening trumpets" which were towed under water and picked up propeller sounds. The noises made by the rush of water across the trumpet's mouth drowned out fainter sounds, and it had been necessary to slow down or stop the chaser for listening purposes. By studying the contours of the seal's ears and applying their design to the ears of the hydrophones, their performance was greatly improved.

It was after Wood had his major's commission and was working with the Bureau of Inventions in Paris, in co-operation with all the Allies, that he conceived what has since been variously called the "spider shell," the "spaghetti shell," the "piano-wire shell," and the "parachute shell." It perhaps happily combines, as I see it, the two paradoxical categories of his war inventions. It is certainly fantastic, yet it must be pragmatically sound, since the British were reported to be reviving and using it in the air defense of London in 1940—and international press services were attributing its origin to "Professor R. W. Wood, Johns Hopkins University physicist."

Here's what Wood says about it.

In discussing defense against hostile aircraft with a number of officers of the French air force at one of the aerodromes, in November, 1917, I suggested that experiments be made with shells containing a coil of steel piano wire—the shells to be constructed like the "parachute bomb" in pyrotechnics. One end of the coil was to be attached to the base of the shell and the other to a small silk parachute packed in the nose. On explosion the base would be driven downward, unwinding the coil of wire, while the parachute would open and drift along

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with the long strand of wire dangling below, like the spider that spins a long thread into the breeze, and then floats away carried by his thread. I also suggested this at one of the meetings of the Bureau of Inventions in Paris, calling it the "spider shell," but nothing appears to have been done with the idea at the time. After the war I alluded to it in a number of public lectures on the relation of scientific research to warfare. Several paper patents appear to have been taken out by various parties in the interval between the two world wars. According to press accounts the wire strands used in the present war were not provided with parachutes and would fall rapidly.

During all this hectic time, while Wood was inventing war gadgets and later, when we went in, pulling every possible human wire to get into uniform and actual service "over there," he wasn't neglecting his purely scientific work.

In the early part of the summer of 1916, he was busy in East Hampton developing a new filter for the photography of the planets by ultraviolet light, which he planned to use with the great sixty-inch reflecting telescope of the Mount Wilson Observatory in California. The filter consisted of a cell made by covering the ends of a short section cut from a square glass bottle with plates of "uriol" glass. This cell was filled with bromine vapor, which he had found to be transparent to ultraviolet light but opaque to all other rays capable of acting on the photographic plate.

In late September Wood went with his wife and daughter Margaret to San Francisco, their first visit with the grandparents since before the earthquake in 1906. Wood immediately went down to Pasadena and was quartered in the so-called "Monastery," the sleeping quarters of the observatory staff on Mount Wilson. The sixty-inch telescope was assigned to him for four evenings, and, to his delight, he found Harlow Shapley, who had assisted him in Princeton, now a member of the staff and ready to help him again. The bromine cell was

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mounted on a brass frame directly in front of the plateholder, which covered an aperture in the side of the great tube near the top, the huge mirror of "silver on glass" being at the bottom of the tube. Photographs of Jupiter and Saturn were made with infrared, yellow, violet, and ultraviolet light, the latter showing an equatorial belt on Saturn that had never been seen before, the cause of which gave rise to considerable discussion among astrophysicists. It was finally decided to be a circular cloud of very fine dust that bordered the "ring" on its inner edge.

As this research neared its end, a "terrible" tragedy occurred.

We had cleaned and charged the cell with fresh bromine vapor (Wood says), leaving as usual a drop or two of the liquid to make up the loss due to its slow combination with the beeswax cement. One of us had clamped it in position, and the great telescope was slowly swung into its nearly vertical position. Suddenly there was a crash like that made by a glass bottle shattered on a cement floor. "Good God," we both (I think) gasped. "The bromine cell on the silver mirror." I leaned over the edge of the tube and looked down. Sure enough, on the great circular shining silver surface, five feet in diameter and twenty-five feet below me, there was a large irregular black splotch, some eighteen inches across. There was nothing that could be done at the moment, and I was relieved to see that the spot was not spreading, which indicated the bromine had all been used up. But had the glass surface been damaged? That was the question that caused a sinking feeling in the pit of my stomach. Shapley said that it was his fault, as he believed he had attached the cell, but I insisted (I hope) that it was mine, as I felt sure I had done it. However, it turned out all right: the glass mirror was not damaged, they were planning to resilver it anyway in a couple of weeks, and the amount of silver removed had not caused enough loss of light to interfere with the program arranged for the interven-

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ing time. We felt better when told by the director that worse things than this had happened. One of their mechanics had once let a small monkey wrench fall on the mirror, which made a large nick in the surface.

Returning to Baltimore late in October, he started a new line of investigation with Professor Okano, a Japanese scientist who had been sent to work with him. They investigated what is known as the "ionizing potential" of sodium vapor, which had never been determined. Defined in words, they were to determine the lowest voltage that would cause sodium vapor to glow or emit light in a vacuum tube. The final result was interesting, though they did not feel sure of it until a number of sources of error had been discovered and conquered. A sodium lamp could be operated with an electric potential of only 1.5 volts on its terminals or by one dry cell, provided free electrons were present. Wood had, in 1910, in collaboration with R. H. Galt, one of his students, studied the spectra of the electrical discharge in dense sodium vapor, and been struck by the overpowering brilliancy of the yellow light in some cases. "It was like looking at the sun through a yellow glass," he says. He had dreamed of sodium lamps, naturally, but at the time there was no way of preparing a glass tube or bulb that would not blacken and become opaque after a few minutes' exposure to the corrosive vapor. It was this circumstance that had caused Lord Kelvin to ask, "Have you succeeded yet in taming sodium vapor?" Modern sodium lamps are of course the latest development for street lighting.

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CHAPTER FOURTEEN

Wood Joins the Army as a "Sheep in Wolves' Clothing" and Becomes "a Hell of a Major" Overseas

"Sheep in wolves' clothing" is the name Wood applied to himself and other professors and scientists who were given commissions and uniforms in the World War. Long before we entered it, he'd been helping the War Department with technical advice, and he kept trying in vain to get his friend General Squier, Chief Signal Officer of our Army, to give him a commission and send him overseas. Then came a cable from Paris to the State Department, rubber-stamped by Prime Minister Ribot, requesting that Wood be commissioned and sent to Paris to work in collaboration with the French scientific group that formed the Bureau of Inventions.

"I was in East Hampton at the time," said Wood, and though I (the biographer) have taken two or three shots at trying to tell what happened next, I think it's best and safest to let him go on telling it in his own way.

I had to go down to Washington (says Wood) to take my medical examination and go through all the formalities. I irritated the Medical Corps sergeant who was testing me on eyesight. When he was giving me the test for color blindness and took out a box of different colored pieces of yarn, he produced a red piece and asked me, "What's this?" I answered,

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"Worsted." But in spite of this, I managed to finish the physical examination and returned to East Hampton to await orders. After I had been there awhile, I received a communication from the War Department ordering me to report to Washington again for a mental examination.

I thought this a bit strange, especially as the head of the Signal Corps, for which I was being examined, was General Squier, an old Johns Hopkins man, who should, I thought, be able to vouch for my mental qualifications. So I wrote a letter to Squier. This was answered by some captain who told me in rather brusque terms to do as I was ordered. Squier said afterwards, "You should have written to me at my apartment. I never even saw your letter."

This meant another trip to Washington, where the temperature was something like 101° in the shade. At the end of this rather long and expensive trip, I presented myself in front of a fat man, who gave me a mental examination, which, as I remember, consisted of the following dialogue:

Q. "What is your name?"

A. "Robert W. Wood."

Q. "What is your occupation?"

A. "Professor of Physics at Johns Hopkins University."

"That's all," he said, completing the record.

This whole business naturally irritated me a good deal.

The irritation, as Dr. Wood realized and faithfully mentions, was mutual. I am informed from other sources that after the door had closed on him, an unhappy sergeant said, "I don't care whether he's the greatest scientist on earth, he's going to make a hell of a major! I'd hate like hell to be his colonel."

I don't know how much his colonel suffered, but quite a while later in the palatial diner on the Blue Train going up from Toulon and Marseille—according to Dr. Hugh Young, who was present—Major Wood was invited to meet General Pershing for the first time and have coffee with him. The

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commander in chief inquired what outfit Wood was with, and Wood is said to have replied, "Well, I suppose I'm what you would call a sort of free lance." "And just what are you doing?" Pershing asked. And Wood is reported to have replied, "Well, sir, it's supposed to be a secret, but I don't think there'd be any harm in letting you in on it."

Wood had obtained his major's commission promptly as red tape went and was soon rigged out in a fine new Rogers Peet uniform. Robert Wood, Jr., a student at Harvard in 1915, had gone to France as a volunteer in the American Ambulance Field Service, had had himself transferred, became an artillery officer with the French, won the *Croix de guerre,* was gassed, and recovered. There are doubtless many cases of father and son who both served as officers overseas, but these two happened to be the first I'd ever met, and I enjoy it when they exchange reminiscences of those old days. They don't do it often—and when they do, they usually get into violent arguments.

Sailing orders came for Wood, Senior, in August, directing him to join a group of Signal Corps officers who were to sail September 9, 1917, on the *Adriatic.* Like most of Wood's experiences with military routine, this embarkation seemed to him puzzling and illogical. He was ordered on board two days before the boat was scheduled to sail—all with the greatest secrecy. The ship was docked on West Street in New York in full view of a group of saloons kept by German-Americans. If there were spies around, Wood reasoned, they would be in touch with the proprietors of these saloons, all of whom must have been able to see that the *Adriatic* was still in dock and that company after company of officers and men had gone on board. Wood says they could swarm all over the decks until the *Adriatic* started down the river, but once it got under way, they had to go below for fear some spy might be on the Jersey shore with a telescope. Finally, with all hands below and no smoking allowed, the *Adriatic* steamed down the North River

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and on its way to Halifax, where they were to join the other seven ships of the convoy.

I quote from Wood's notes.

Several days out from Halifax harbor, we had our first boat drill. Each lifeboat and raft was put in command of an American officer; why I don't know. "Our little group" consisted of Professor Augustus Trowbridge of Princeton, one of my closest friends since Berlin student days, Professor Theodore Lyman of Harvard, and three men from the Western Electric Company, Buckley and Shreeve in uniform and Colpitts in civilian disguise! Trowbridge and I were put in command of a life raft and its adjacent boat respectively, and I was ordered to bring the army squad assigned to my boat from the lower deck to the boat deck at 3:00 P.M. When the time came I discovered, to my relief, a sergeant in my group, and I ordered him to bring the squad to Boat 12 on the upper deck, for I felt sure that if I attempted to accomplish the maneuver I should end by marching the squad over the rail and into the ocean. After the drill was over, I dismissed my squad, and Trowbridge and I went below and had a couple of drinks. Later on I went up to the boat deck for a breath of air before dinner, and discovered Trowbridge's squad still standing at ease by the boat. "What are you men doing here?" I asked. The sergeant grinned and said, "We've not been dismissed, sir."

We sailed on night after night, the weather growing colder and colder, and the North Star climbing toward the zenith. One afternoon it occurred to Colpitts that it was the night of the autumnal equinox, on which both latitude and longitude can be calculated from the elevation of the North Star and the time of sunset. I made a quadrant out of two sticks of wood and a protractor. By sighting one stick on the horizon and the other on the star, I determined its elevation, given which Colpitts, who had timed the sunset, worked out our

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position in a few minutes. This news spread rapidly in the smoking-room, eventually reaching the bridge, throwing the ship's officers into a frenzy, as all information regarding the course we were sailing was a dead secret. Next morning we discovered the ship's officers had set all of the clocks available to passengers three-quarters of an hour ahead, to confuse and baffle the scientists aboard.

One afternoon we were asked to have tea with the Captain, who told us the destroyer escort would pick up our convoy about half past seven. By seven everyone was on deck scanning the horizon. Presently someone said, "There they are," and sure enough there they were, four tiny black matchsticks outlined against the sky. Presently another four, a little to one side. So great was the speed of approach that you could visualize the curvature of the earth. It was almost like watching a motorcar coming over a hill top. Presently they were all around us, and one slim gray craft with a wicked-looking, scarlet red, four-inch gun in her bow slipped by within a few yards of the *Adriatic,* and five hundred Americans cheered themselves hoarse.

After a dramatic trip from Liverpool to Southampton in five trains, each with a double locomotive, they finally arrived at Havre at five on a September morning, and were ordered to proceed to British Rest Camp No. 2, which they were told was on top of a hill about two miles from the city. There they were to await orders for transportation to Paris.

They waited on the dock for some time and then began to question themselves whether "the long, low, gray cars" which were provided as transportation for officers in the stories of war correspondents would materialize! Finally, they realized that they were expected to go on foot. So they marched up the dock, feeling very important—four majors and a captain, all in brand new Rogers Peet uniforms—with their coats unbuttoned and their hands in their pockets.

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As they reached the head of the dock, a British sergeant who was washing his face in a basin in front of a British barracks looked at them with a grin, and, making a trumpet of his hands, bawled out in a voice that could be heard at the extreme end of the barracks, "Jesus Christ! *Look* who's here!" The Americans, saving what little face they had left, passed on looking straight ahead, pretending they had not heard him.

A little further on they passed a detachment of British soldiers who were escorting a squad of German prisoners from the docks to the barbed-wire barricades. Several German officers were among them, and as they passed the group, they heard one officer say in German to his companions, "I wish I could take one of them home with me for a souvenir."

Wood had neglected to obtain authorization to report directly to the French Bureau of Inventions which had asked through the State Department to have him commissioned and sent over. Had he not neglected this, it would have freed him from a lot of red tape. As it was, he was forced to report to the Chief Signal Officer of the A.E.F., General Russell, then in Chaumont. But he managed, partly by playing hooky, to get in touch and keep in touch with most of his internationally uniformed professorial colleagues—with the other "sheep in wolves' clothing."

Here now comes a lot of unadulterated Wood, concerning what war research was—and probably still is today—among scientists and physicists. It presents a sad and at the same time stimulating picture.

Says Wood:

Along with the really valuable research that was going on there was a lot of futile or crazy war research, very technical, most of which never amounted to anything. I was continually reminded of Gulliver's voyage to the island of Laputa, where crazy scientists were working on crazy problems.

The laboratories of the Sorbonne, Ecole normale, Collège de

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France, and other institutions of learning in Paris were peopled by scientists, old and young, most of them in the horizon-blue uniforms of the French Army, puttering around on things to make war simpler, faster, or more frightful.

Captain Bougier was working on a device for determining the direction from which hostile aircraft were approaching by causing the sound vibrations falling on two widely separated horns to vibrate two light mirrors mounted at right angles to each other; a beam of light reflected from one mirror to the other and then to a screen traced a more or less complicated curve known to physicists for the past half century as a Lissajous figure, from the shape of which the direction of the source of the sound could be determined. I made a slight improvement in this apparatus by placing the mirrors closer together and viewing a minute source of light directly in the second mirror. The French now needed an instrument imitating the sound of an airplane for testing these and other direction finders. I said, "Why not use an old airplane?" (This same problem came up years later in the broadcasting studios. The sound-effect experts had spent fruitless days in searching for something that would imitate the sound of an opening or closing door, and finally agreed that the only thing that would imitate the sound perfectly was a *door;* in every studio you now see a little door about three feet square, with handle and latch complete, on a frame which rolls on rubber-tired wheels. Opening and shutting this does the trick.) Some objection was raised against this obvious solution, and I constructed in a half hour or so a horn made by separating the trumpet and sound box of a "Strombos" auto horn, operated by compressed carbon dioxide, and inserting a brass tube about three feet long between the parts. This, when operated by the compressed gas, produced a low note of about 120 vibrations a second, and imitated the low hum of an airplane quite perfectly. They liked this very much, as it could be carried anywhere under the arm. When operated in the laboratory

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the effect was very peculiar. Stationary waves were produced. At some places its roar was very loud, and at other places only a few feet away there was almost complete silence. We used to poke it out of the window at noon and turn it loose, and the crowds going to lunch down the "Boul. Mich." would stop and gaze skyward in alarm. (This was the progenitor of the subaudible horn I made later for John Balderston for stage effect.)

Professor Jean Perrin, Nobel laureate, now disguised as a *Commandant* in horizon-blue uniform with red and gold tabs, but, with his white hair and beard and perpetual good humor, looking more like Santa Claus than an officer, dashed back and forth between his laboratory and the proving ground at St.-Cyr in a military car driven at a furious pace and squeaking "toot-toot" every five seconds like a Paris taxi. He was testing his gigantic "loud-speaker" or honeycomb horn, as we called it. Hundreds and hundreds of little hexagonal horns were gathered together on a plane like the cells of honeycomb, with tubes of *equal length* leading to a single mouthpiece, the idea being that the sound would emerge from each trumpet at the same instant, and consequently would go off into space as a parallel beam like the rays of a searchlight. It was a terrific contraption, with its tangled network of twisted brass tubes, and did not work much better, it seemed to me, than the big ten-foot megaphone with which we used to sass the policemen two or three blocks away when I was a student at Johns Hopkins. After the armistice I tried to induce the French to present one of these to the War Museum of the Smithsonian Institution, but they wanted three thousand dollars for it!

The great flat collection of small hexagonal trumpet mouths must have been eight or ten feet in diameter. It was pointed down the field, and a narrow-gauge railway led away from it, on which operated a hand car, with two officers, armed with pens and notebooks, who recorded the distance at which they could hear speech correctly. The device was designed to enable

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a commander to give orders during the din of battle. How this gigantic acoustic engine on its great truck would have fared in battle seems open to question. *"Gutenberg soixante quatorze deux zéros,"* bellowed Perrin through the cells of the honeycomb. The observers, three hundred yards away, entered this Paris telephone number in their ledger, and drew away, pumping their hand car vigorously. *"Louvre quatre-vingts soixante et un,"* thundered Jove again. This went on for some time, when the hand car dashed back to report observations, and I, who had been standing directly in front of the horn, told Perrin I had been learning French by a surgical operation.

Then there was Chilofski, who was experimenting with a seventy-five millimeter shell fitted with a slender rod in front, at the tip of which a flame of burning phosphorus streamed back over the shell during its flight. This was supposed to decrease the air resistance and increase the range. Since he could not fire the shells in his little laboratory from a "seventy-five," he mounted them on the arm of a "dynagraph" and secured records of the pressure exerted by a blast of air having a velocity of 1,200 feet per second, with and without the flame. These tests showed a marked decrease in the pressure, but ballistic experts have since told me that an equal decrease could be obtained by giving the shell a long, tapering point.

The work of Professor Paul Langevin was much more promising, however. He was developing a method of locating submarines by sweeping the sea, under water, with a narrow beam of high-frequency sound waves, and picking up the "echo" reflected from the submarine by suitable electrical apparatus. As I had asked permission to devote particular attention to this work, I spent more time with Langevin than with the others. We went together to the Naval Arsenal at Toulon where the apparatus was in operation. The source of the supersonic vibrations was a system of square quartz plates properly oriented and cemented side by side to a steel disk. The quartz plates have the remarkable property of expanding and con-

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tracting when the opposite sides are put in electrical contact with the terminals of a high potential electrical generator, at the same frequency as that of the electrical oscillator. In this way sound waves of such high frequency can be caused to radiate from the steel disk that, instead of spreading out in all directions, as do audible sound waves, they are projected in a narrow beam. We saw fish die and turn belly up when they swam across the beam, and if a hand was held in the water in front of the plate, there was a painful burning sensation in the bones.

Throughout all this time, Wood's chief, General Russell, who had the military martinet's horror of anything that savored of free-lancing, had been trying to hold Wood in one groove. He had sensed, however, the great importance of Langevin's work, and had willingly let Wood give all the time he wanted to that. The Creusot gun works had asked the Bureau of Inventions for suggestions on a method to measure the pressure in high caliber guns, from point to point, as the shell traveled along the barrel. Wood suggested the insertion of piezoelectric cylinders of quartz, each of which would give out an electrical impulse of magnitude proportional to the applied pressure. This method is standard procedure today, and is generally ascribed to Sir J. J. Thomson, who developed it independently in England a year or two later. It was fortunate for pure science that General Russell gave Wood free rein with Langevin, for it led later to the important researches in supersonic vibrations which were carried out by Wood and Alfred Loomis in the latter's laboratory at Tuxedo Park in 1927.

There was a good deal of shuttling of scientific and technical officers back and forth across the pond, and toward the end of the year Wood began to feel that he could obtain better laboratory facilities and consequently be more useful for a while back in America. So he applied for transfer, and arrived in New York in January, 1918.

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He stopped in on Professor Michael Pupin of Columbia University, the great electromechanical wizard, who was working for the Navy on submarine detection. Pupin was interested in hearing of Wood's work with Langevin and spent some time, with his staff, getting the details of the piezoelectric quartz vibrations.

He wanted Wood to work with them at their laboratories at Columbia and asked General Squier, Chief Signal Officer of the Army, if he might stay. But Squier refused. He wanted Wood to work in his own laboratory on his own ideas, realizing that he worked best as his own boss. As there was no use stifling the originality of a versatile man under mountains of Army red tape, Squier assigned him to detached service in Baltimore.

Here he developed the first device offered by the Science and Research Division which was actually put into production for use overseas. The Signal Corps of the army needed, among other things, a blinker-type signal which would not spread its beam so widely as to enable the enemy to read its messages. Their standard signaling lamp was something like an automobile spot lamp. It threw its beam far enough, but spread it so widely that there could be very little privacy at the receiving end. This made it impossible for the Army to use it in the trench warfare then in progress on the Western Front in France.

So Wood devised and made the "flash telescope," a signaling device which projected a beam of light the width of which at a distance of a mile was less than ten feet. On looking into the eyepiece the distant landscape, highly magnified, and the minute coiled filament of the lamp were both seen in good focus. The telescope was aimed by bringing the point at which the signals were to be received, say, a window of a ruined house, into coincidence with the filament and then clamping the telescope on its tripod. The first model was made up of a piece of galvanized iron stovepipe, a six-volt auto lamp bulb

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(later replaced by special hydrogen-filled lamps which were made to cool quickly for quick flashes), a fairly good achromatic lens from an old projection lantern, and a good eyepiece.

Wood took it to Washington and showed it to General Squier. There it was tried out in the presence of officers of the Signal Corps; two of them stood ten feet apart, at a distance of a mile, and the lamp was clearly visible to one and not to the other. This old-junk lamp was sent over with some other apparatus and was demonstrated at the battle of Seicheprey, where it sent signals back to Divisional Headquarters at a distance of five kilometers from the front-line trenches during a German bombardment. An immense French signaling lamp had failed to make satisfactory contact at this range. Winchester, the American officer who took the Wood lamp over, established communication in five minutes after his arrival on the scene. Pershing immediately ordered a hundred of the new signaling lamps to be manufactured and sent over. They were wanted of course for signaling from the rear to front-line positions.

Winchester also took over with him a very dark red signal light invented by Wood. Its signals could be received in daylight only by field glasses equipped with special dark red filters. Another lamp developed by the Baltimore Station projected a beam through an ultraviolet filter, which could be received only on a special phosphorescent screen. These last two lamps so intrigued Signal Corps officers in France that they insisted they be incorporated in the original lamp, and it was this which resulted in so complicating its construction that the job was not finished until just before the armistice.

Although of no practical use to American troops at the time, the research incident to making the ultraviolet lamp resulted in the discovery of a totally new type of glass, now the standard in thousands of scientific and industrial applications of ultraviolet light. The original batch of five hundred pounds

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was melted at the Carr-Lowry Glass Company in Baltimore, under Wood's supervision. Corning at about the same time developed a similar glass independently, but later changed their batch formula as the result of suggestions from Kettering of the General Motors research laboratories, who had been in communication with Wood.

While Wood was experimenting on this new glass, he was troubled by the fact that he was spending too much of the government's money on crucibles for melting small batch samples. In an attempt to economize, he found he could replace this costly laboratory ware with unglazed coffee cups, which could be had from a local pottery in gross lots at a few cents apiece.

He was just beginning to congratulate himself on his thriftiness when the government forced him to spend $30,000 merely to prove he was right when he insisted on the impossibility of making a hot-air sausage balloon!

Of this episode, Wood says:

It seems that a crackpot had, for some months, been pestering the air force of the Army and Navy to give a trial to his scheme of inflating an observation balloon with hot air instead of hydrogen, thus rendering it fireproof against attack by phosphorus incendiary bullets. His plan was to install a long iron pipe inside of the "sausage" along the bottom of the bag. This pipe was to supply gasoline vapor to huge Bunsen burners rising from the pipe, the flames heating the air with which the balloon had been filled. The Army and Navy said no over and over again, so the crackpot did what all discouraged crackpots do—he got some congressmen interested in his invention, and the congressmen said to the Army and Navy, as they always do, "This man's invention must be tested. Army and Navy officers are old fogies, too conservative. Don't appreciate genius. Our army must have it, or he'll sell it to the enemy," etc., etc. And the Army said, "O.K., have it your own

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way," as the Army and Navy are apt to do when a congressional committee gets after them. But the air force was too busy with more important work to make the test, so they passed the buck to the Science and Research Division, saying, "Give the guy a break and test his invention," and the officer commanding the division assigned the job to the Baltimore Experiment Station. I begged to be excused, saying that the idea was preposterous: the weight of the pipe, fuel, etc., could never be lifted by hot air, even senatorial hot air. I showed that the temperature would have to be so high that the fabric of the balloon would burn, but was told that the Bureau of Standards had already made preliminary experiments and had found that you could have a "temperature gradient," i.e., very hot air in regions not too near the fabric. I was shown the apparatus. It was a box the size of a trunk lined with asbestos, filled with heating coils of wire and bristling with thermometers. I said, "No, *No,* and NO. You will have a convection current of hot air from the long gasoline burner rising in a sheet and breaking against the top of the bag, which will char the rubberized cloth before the buoyancy will be sufficient to even lift the balloon fabric alone, without the weight of the observer, iron pipe, gasoline tank, air compressor, and other paraphernalia." It was useless, however, and Lieutenant Paul Mueller of the balloon section, a sergeant, and four privates, one of them Edison Pettitt, now a very distinguished astronomer at the Mount Wilson Observatory in California, were assigned to the Baltimore Experiment Station. They came over at once, and were very useful in connection with the construction of the various signaling devices during the months occupied in the erection of the balloon hangar. This was taking shape over the concrete floor, which had been laid on an unused part of the university campus, and a five-inch gas main brought in from Charles Street, distant some three or four hundred yards, with a special gasometer as big as a large wardrobe trunk. The burner tube

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was a three-inch iron pipe supported at the center and running the whole length of the standard observation balloon sent over by the air force.

Finally after months of labor the day came for the test. Mueller and I crawled inside of the big bag which had been pumped full of air and was resting on the floor. We ordered the gas turned on, and held our burning torches over the burners nearest the central vertical pipe of the long-armed T. As soon as these blazed up we ran rapidly, Mueller north and I south, lighting burner after burner as quickly as we could. When all were going we hurried back to the air trap which was the only means of escape. It was a fine sight. We were inside of a great cylindrical tent, partly luminous by transmitted daylight, which showed the geometrical patterns of the overlapping sections of the balloon fabric, and partly illuminated by the great blue gas flames, which were tipped with yellow and fluttered with a dull roar. I had my camera of course, and by the time I had set up the tripod, focused, and made the three-second exposure, it was getting pretty hot and very "close" inside the balloon. We crawled out through the air trap and drew several very long breaths. Our crew, augmented by a half dozen volunteers now, lifted the big bag from the ground to estimate its diminishing weight. It was not attached to the heavy burner, or to anything else, and just as it was showing an inclination to be self-supporting, I smelt a strong odor of burning rubber. Letting go of the supporting rope which ran along the side of the bag, I stepped back. A cloud of blue smoke was rising into the air all along the top of the balloon. "Shut off the gas. It's all over—finished." We had used possibly a dollar's worth of gas, but the "test" had cost the government $30,000, we afterwards learned. The photograph, however, was a great success.

Wood still had his yen for flying, despite the fact that in the 1912 naval flight with Tower—in an old box-kite Curtiss

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machine made with "strips of bamboo, piano wire, and bicycle saddles to sit on"—he had gone up over three thousand feet and came down (next morning) with the mumps. He now had a legitimate pretext in a lamp he'd invented for testing the use of ultraviolet rays in blind landings. He took it to Langley Field, near Norfolk, for the test flights, and was invited to go up in the afternoon for some stunt and acrobatic flying. They told him he could choose between Major So-and-So of the Air Corps, who was a great war-stunt acrobat, and Art Smith, the barnstorming circus pilot whom he'd seen sky-writing at the San Francisco Fair in 1916. . . .

Says Wood:

I chose the major, since I was in uniform myself and felt it would be more dignified to be made a monkey of—or crash—with a fellow-officer than with a circus man! As the machine took off, a lot of grinning officers came out with field glasses prepared to watch me suffer and doubtless hoping I'd get sick, which was a usual part of the fun. At three or four thousand feet we did about everything except straight upside-down flying. Loops, multiple loops, Immelmann turns, etc., ended with a proper spinning nose dive which interested me enormously, as the plane seemed merely plunging straight down without spinning toward an earth that was rotating like a great turntable, with the rim of the horizon whirling at what seemed to be twenty-five miles per second! Our morbid spectators were disappointed, I fear, despite the beauty of the stunting, for I hadn't the expected dizziness and nausea.

Late in the evening I made the serious flight, in a thunderstorm, with an Air Corps lieutenant, for the purpose of testing my ultraviolet landing beacon. In the course of the flight, the pilot looked back at me, made a circular gesture with his arm, and nodded. I thought he was asking if I wanted to loop, and shook my head vigorously. I'd had all the looping

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I wanted in the afternoon. In about two seconds I discovered that he hadn't been asking me—he'd been telling me. Down we plunged, and then sweeping up, we practically stalled at the top of the loop. I dangled by the straps as the plane hung upside down for a second or two. When we landed, the pilot said, "Well, how did you like it?" "Fine," I replied, "but that was a rotten loop you made." "I thought so too," he replied cheerfully. "It was the first time I ever tried it . . . at night."

Major Wood was working with General Squier's Signal Corps in America when the armistice came. After the armistice, in February, 1919, Wood decided he wanted to return to France and see what four years of war had done to the country. It occurred to him it would be interesting to see what scientific instruments he could collect for the War Museum of the Smithsonian, either in London and Paris or in the German trenches and dugouts of the battlefields. This served as a plausible excuse for going over, and he was given a special passport. The start of this chimerical expedition is told in a letter to his wife.

When we docked at Liverpool who should come on board with a couple of British intelligence officers, but Captain Robb, whom I had known years before at Cambridge. . . . He said not a room was to be had in Liverpool or London, but he had a big room with two beds and would take me in for the night. Two hundred and fifty first-class passengers went ashore, where they went then I can't imagine. Went up to London the next morning and telephoned to a dozen hotels. Tonight I dine with Boys at the Royal Society Dining Club, after the meeting of the R. S. in the afternoon. Lord Rayleigh and everyone else will be there. I'm down for a talk at the Physical Society on military signaling with invisible light. None of my scientific friends who are on the British Inventions Board ever heard my name mentioned in connection with any of the suggestions or inventions I sent over. They were surprised to find I had been in military service. A special branch has been established to develop one of my things, and I've been

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asked to go down to the Portsmouth Navy Yard tomorrow for a conference with the naval officers in charge.

Yesterday I was taken to a secret bureau, the laboratories of the base-censor. . . .

Here's the story Wood tells me about what happened at the Base Censor Bureau.

One of its departments made tests of suspected passports and other dubious documents for erased writing, superimposed writing, invisible inks, etc. They also tested similarly shirt fronts, cuffs, handkerchiefs, linen of suspected spies—even panties and petticoats if the suspected spies were female. These articles of apparel might have been written on with invisible ink—or they might have been treated with chemicals which could be used in making invisible ink when soaked in water —to be used elsewhere for invisible writing and later developed by another chemical. The British experts showed me all the various chemical methods in use for developing secret writing. They showed other interesting activities, and I was waiting with some anticipation to see what was going on inside a small cabinet with no window which stood in the middle of the laboratory with wires running through the wall and along the ceiling. I suspected its use, and finally, when no mention of the cabinet was made at all, I asked, "What goes on in there?"

"Oh, I'm sorry," said the captain who was showing me about, "but that's *very* secret. We don't show that to anybody."

"Ultraviolet light, I presume," said I in a detached manner.

"What!" said the amazed captain. "What makes you think so?"

"Because I invented the method and the black glass that cuts off the visible light, and sent the formula to your Admiralty from our Science and Research Division over a year ago."

"Will you wait a moment," said the captain, "while I speak to the colonel?"

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I was presently ushered, with suitable apologies, into the dark room.

They had a quartz mercury arc in a box, with a window of dark-blue cobalt glass, under which they placed a German passport. When you looked at it through a yellow glass plate which cuts off the blue light reflected from the paper, you could see here and there German words, not supposed to be on any passport, which gave off a small amount of yellow light when stimulated by the violet rays. I remarked that this was the method of detecting fluorescence employed by Sir George Stokes more than half a century before. I asked why they did not use ultraviolet light to start with, which produces a strong fluorescence and is invisible.

"I'll show you what I mean," I said. "Come back into the dark room." I happened to have a small plate of my black ultraviolet glass in my pocket, and we fitted it before a hole in a sheet of cardboard and stood it in front of the lamp window. The passport was now seen to be covered with previously invisible writing, practically all of the German words shining with a pale blue light.

"But where can we procure those plates?" they asked.

"I don't understand why you haven't got them," I replied. "Your government has them. I sent the formula over a year ago to the Admiralty. A lot of them have been made and are in actual use at your Portsmouth Navy Yard. . . ."

"Oh, but you know," said they, "the liaison between our Navy and Intelligence Department is not as good as it might be. We'll call up Portsmouth and see if they can supply us. . . ." Portsmouth obliged at once.

By this time, it seems, they were not only keenly absorbed but also a little on the defensive for the moment. So they proudly explained that they had devised a note paper on which it was impossible to inscribe secret writing. This paper had been on sale at all post offices, and letters written on it

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were not subject to the long delay necessary for applications of their various tests for secret writing. This paper had proved very popular, as the letters passed the censor immediately. It was ordinary note paper on which fine parallel lines had been printed close together, in pale red, green, and blue ink—the red being soluble in water, the green in alcohol, and the blue in benzine. (The paper looked gray to the naked eye.) Since practically all liquids employed for making invisible writing fall into one of these three classes, one set of colored lines must dissolve in the colorless fluid flowing from the pen and produce colored writing. I recalled I had discovered years before that the pigment Chinese white comes out black as charcoal in photographs made with ultraviolet light, so I said, "Suppose I write on it with a fine crayon of Chinese white; then none of these lines will dissolve, yet it can be read by photography."

"Oh, no," they told me, "you can't even write on it with a toothpick or glass rod without making legible writing. The colored inks are made slightly soft or 'tacky,' so that they smear together and produce dark gray letters. Here, try to write on it with this glass rod."

I tried to write invisibly with the glass rod, and failed, but was obstinate in my belief I could write on it invisibly with something. I had an inspiration and said,

"I still think I can beat it if you'll let me try again."

"Impossible!" they said. "We've tried everything."

I said, "Well, let me try once more. Bring me a clean rubber stamp and some vaseline."

The large, smooth, clean rubber stamp was brought. I smeared it with vaseline, then wiped it carefully with a cloth until it made no visible grease mark on paper. Then I pressed it down firmly on the spy-proof paper, taking care not to let it slip sideways.

"Can you discover any writing here?" I asked.

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They studied it by reflected light and by polarized light and said, "Nothing here."

"Now let's look at it with the ultraviolet," I said. We took it into the cabinet and held it in front of my black window. In brilliant blue letters, as if the nice clean rubber stamp had just been pressed on its own ink pad, stood the words:

NO SECRET
WRITING HERE

Professor Wood, now in mufti and with a discharge paper indorsed "Honest and Faithful," began traveling again over the battlefields in the war zone to see whether any signaling apparatus used by the Germans could be picked up. He started off in an Army Cadillac with Lieutenant Winchester and Dike of the American Embassy.

They went through trenches and down into dugouts, but the only pieces of German optical apparatus they discovered were primitive signal lamps for giving a narrow beam, made out of old brass shell cases, with a candle at the bottom and a narrow slit in the side.

Of Wood's final days in Europe after the war, he writes:

Before leaving Paris I was asked to give a lecture with demonstrations at the Sorbonne. The war was over, and "Now it could be told." The show came off on May 18 in the large lecture hall, before an audience of two hundred or more, composed of physicists and army officers, some with their ladies. With the room darkened and a very powerful ultraviolet lamp, I flooded the audience with what the French had named *Lumière Wood,* causing teeth and eyes to phosphoresce brilliantly, and various textiles to shine with subdued colors. A lady's dress in the center of the hall glowed with a brilliant scarlet color, attracting much attention. Everyone was looking at the glowing teeth and eyes of their neighbors, and a wave

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of laughter swept the hall when I explained that false teeth appeared as black as charcoal in the light. With a flash telescope, I demonstrated the narrow beam of light, and the lecture closed with *"Vive la France,"* rapidly executed with the spot of light on the wall in Morse code, which was read by a sufficient number of officers to cause applause.

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CHAPTER FIFTEEN

The Woods Cover the World—The Barn Spectroscope Moves to a Palace—And Pussycat Loses Her Job

Wood's fiftieth birthday had occurred in the year of the armistice. The years which followed saw him entering an era of speeded-up activities, scientific and social, which would have left most younger men out of breath and panting.

He detests the word "social" and "society," but this petulance doesn't alter the fact that he and the whole family have always loved parties and gaiety. By 1918 they had become international cosmopolites, shuttling in the summertime from great country houses in England to Paris and Brittany, to St.-Jean-de-Luz, to St.-Moritz in winter, playing with the most dazzling playboys and playgirls of the period as well as consorting with fellow-celebrities in Wood's own world of science.

A complete record of the Wood family's ocean trips, parties, visits to Aix-les-Bains, Baden-Baden, Biarritz, Venice, and the Lido during the twenties and thirties would give the false impression that Wood himself was an international playboy. Yet it was during these same years that he conducted many of his most important researches and made some of his greatest contributions to science. The man is definitely a hyperkinetic, yet never burns out his fuses.

Wood was no sooner out of the army and back in Baltimore than he took up his work with sodium where he had

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left off before the war. In 1919 he announced the discovery that thin films of metallic sodium and potassium, condensed on the inner surface of fused quartz bulbs at liquid-air temperature, while so opaque to light that the sun was invisible through them, were transparent to the entire range of the ultraviolet as far as wave length 2,000. The discovery was of considerable importance in connection with the new theory of the optical properties of metals. At the same time Wood became interested in the mystery of the hydrogen spectrum—the fact that while all terrestrial sources of luminous hydrogen gave spectra with only eight of the so-called Balmer series of lines, the spectra of the sun's chromosphere and many stars showed thirty-three members of the series. The result of his investigation is such a good example of how research in pure science can have immediate practical importance that I let him tell it himself.

Bohr, the great Danish physicist, whose explanation of the Balmer series of hydrogen had created a sensation at the Birmingham meeting of the British Association, had told me that he believed that the absence of the higher members of the series in vacuum tubes might result from the circumstance that the atoms were too close together to allow room for the larger electronic orbits, which, on his new theory of radiation, were responsible for the shorter ultraviolet radiations, whereas in hydrogen stars there might be room for these orbits owing to the lower pressure of the gas. This didn't seem a promising line of attacking the problem in the laboratory, since the luminosity in a vacuum tube decreases enormously as the pressure is lowered, but I decided to give it a trial.

To make up for the loss of light, which was sure to result from the lowering of pressure, I made a tube over three feet in length. The two ends, terminated by large bulbs for the electrodes, were bent at a right angle, so that light from the entire tube could escape from a small, thin-walled bulb blown at the

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bend. The tube was excited by a powerful high-potential transformer, but when pumped to very low pressure showed only two or three of the Balmer lines and a host of the hundreds of lines that we now know are due to molecular hydrogen. This was clearly the wrong idea, but at higher pressures, the lines that I wanted came out much stronger, and the other lines grew fainter, and conditions seemed to be improving from day to day. Moist hydrogen was flowing into the tube all the time through a long tube the size of a horsehair, and the pump was working at the other end continuously. On the third day the central part of the tube was shining with a fiery purple color of almost unsupportable brilliancy, the spectroscope showed that only the Balmer series of lines were being emitted, and I eventually succeeded in photographing twenty-two members of the series, more than doubling the number previously found in the laboratory. Further study showed that the improvement resulted from the circumstance that only hydrogen *atoms* were present in the tube. These emit the Balmer lines, while the molecules, which consist of two atoms bound together, give a very complicated spectrum made up of thousands of lines. These, and the continuous background which accompanies them, were the cause of the obliteration of the Balmer lines of shorter wave length in all previous work. As the work proceeded I found that the success of the operation resulted from the fact that the atomic hydrogen formed by the powerful discharge could combine into the molecular gas only by coming in contact with the walls of the tube or the aluminum electrodes. The central part of the long tube was so far removed from the electrodes that they were inoperative in this region, and the water vapor, which entered along with the hydrogen, formed a film on the walls, which "poisoned" them, as Langmuir pointed out, so that they were no longer operative in recombining the atoms into molecules.

The most remarkable observation of all was made when a short loop of fine tungsten wire had been mounted in a short

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side tube, for another experiment. It was to be heated white hot by a storage battery to see whether shooting free electrons into the discharge would have any effect. To my amazement the wire remained white hot after I had opened the switch to the storage battery, though it was not in the line of the discharge, but in a little side tube. Aston, the English physicist, happened to come into my room at the moment, and opened his eyes when he saw what was happening. He suggested that a parasitic discharge might be flowing from the main current to the battery, which was still connected by one wire with the tungsten filament, so I disconnected both wires where they were attached to the tungsten; but the filament continued to shine like an automobile lamp. It turned out that the tungsten was causing the recombination of the hydrogen atoms into molecules, and the heat of recombination was sufficient to maintain the wire at a white heat. The results of these experiments were published in two papers in the *Proceedings of the Royal Society*.

Shortly afterwards I demonstrated the effect before the research staff of the General Electric Company at Schenectady, making the vacuum tube on the spot. As I showed it here the tungsten filament was mounted in the side tube leading to the pump. The pressure was only about $\frac{1}{700}$ of that of the atmospheric, and the atomic gas was practically at room temperature, yet the wire was kept at incandescence by a cold stream of atomic hydrogen. Dr. Langmuir was much intrigued and began to speculate on what could be accomplished with a stream of the gas at atmospheric pressure. His speculation led to an important invention, for in less than six months he took out a patent for an atomic hydrogen welding torch, which proved of immense value, since all sorts of metals could be welded in a hydrogen atmosphere without showing flaws or blowholes.

It was as a consequence of Wood's scientific zest and social strenuousness that fate brought him, about this time, the fa-

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cilities of a great private laboratory backed by a great private fortune. He had met Alfred Loomis during the war at the Aberdeen Proving Grounds, and later they became neighbors on Long Island. Loomis was a multimillionaire New York banker whose lifelong hobby had been physics and chemistry. Loomis was an *amateur* in the original French sense of the word, for which there is no English equivalent. During the war, he had invented the "Loomis Chronograph" for measuring the velocity of shells. Their friendship, resulting in the equipment of a princely private laboratory at Tuxedo Park, was a grand thing for them both. To say that the conjunction was like that of Leonardo da Vinci and Lorenzo the Magnificent would be a wrong comparison, since Wood's nature is such that not even God Almighty could ever be a *patron* to him.

A happy collaboration began, which came to its full flower in 1924. Here is Wood's story of what happened.

Loomis was visiting his aunts at East Hampton and called on me one afternoon, while I was at work with something or other in the barn laboratory. We had a long talk and swapped stories of what we had seen or heard of "science in warfare." Then we got onto the subject of postwar research, and after that he was in the habit of dropping in for a talk almost every afternoon, evidently finding the atmosphere of the old barn more interesting if less refreshing than that of the beach and the country club.

One day he suggested that if I contemplated any research we might do together which required more money than the budget of the Physics Department could supply, he would like to underwrite it. I told him about Langevin's experiments with supersonics during the war and the killing of fish at the Toulon Arsenal. It offered a wide field for research in physics, chemistry, and biology, as Langevin had studied only the high-frequency waves as a means of submarine detection. Loomis

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was enthusiastic, and we made a trip to the research laboratory of General Electric to discuss it with Whitney and Hull.

The resulting apparatus was built at Schenectady and installed at first in a large room in Loomis's garage at Tuxedo Park, New York, where we worked together, killing fish and mice, and trying to find out why and how they were killed, that is whether the waves destroyed tissue or acted on the nerves or what.

The generator was an imposing affair. There were two huge Pliotron tubes of two kilowatts output, a huge bank of oil condensers, and a variable condenser with intersecting wings of the type familiar to every amateur radio operator, but about six feet high and two feet in diameter. Then there were the induction coil for stepping up the voltage and the circular quartz plate with its electrodes in an oil bath in a shallow glass dish. With this we generated an oscillatory electric potential of 50,000 volts at a frequency of from 200,000 to 500,000 alternations per second. This oscillating voltage applied to the electrodes on the quartz plate caused it to expand and contract at the same frequency, and generate supersonic waves in the oil, the pressure of which against the surface of the oil raised the thick liquid in a mound nearly two inches in height, surmounted by a fountain of oil drops some of which were projected to a height of a foot or more. We could conduct the sonic vibrations out of the oil into glass vessels and rods of various shapes by dipping them in the oil over the vibrating plate, and found they could be transmitted along a glass thread the size of a thick horsehair to a distance of a yard or more. If the end of the thread was held lightly between the thumb and finger, no sensation was produced, but if it was pinched it felt almost red hot, and in a second the skin was burnt white in the form of a groove. A thin glass rod when carrying the waves and pressed firmly against a pine stick caused it to emit smoke and sparks, the rod burning its way through the wood,

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leaving a hole with blackened edges. If a glass plate was substituted for the pine stick, the vibrating rod drilled its way through the plate, throwing out the displaced material in the form of a fine powder or minute fused globules of glass. If the waves were passed across the boundary separating two such liquids as oil and water or mercury and water, more or less stable emulsions were formed. Blood corpuscles were exploded, the red coloring matter escaping and staining the saline solution with which it had been mixed, making a clear transparent red like an aniline dye. These and a host of other new and interesting effects were discovered in the first two years of our experiments.

As the scope of the work expanded we were pressed for room in the garage and Mr. Loomis purchased the Spencer Trask house, a huge stone mansion with a tower, like an English country house, perched on the summit of one of the foothills of the Ramapo Mountains in Tuxedo Park. This he transformed into a private laboratory de luxe, with rooms for guests or collaborators, a complete machine shop with mechanic and a dozen or more research rooms large and small. I moved my forty-foot spectrograph from East Hampton and installed it in the basement of the laboratory so that I could continue my spectroscopic work in a better environment. Mr. Loomis had a new tube made for the instrument, since there was no point in digging up the underground sewer pipes which had served formerly. He packed the tube in boiler felt with an arrangement for keeping the entire tube at a constant temperature, had a new and better camera made, installed motors, revolution counters, etc., for rotating the grating, which was housed in a small closet built around the brick pier on which it was mounted, and arranged other substitutions and gadgets, until I told him there was nothing left of my celebrated spectrograph but the forty feet. It had experienced a "reincarnation," and required no pussycat as housemaid.

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Loomis, who was anxious to meet some of the celebrated European physicists and visit their laboratories, asked Wood to go abroad with him. They made two trips together, one in the summer of 1926, the other in 1928. Going over on the *Ile de France* early in July, 1926, they were met at Plymouth by a Daimler in which they were driven to Hereford for a visit with Wood's friend Thomas R. Merton, professor of physics at Oxford and now treasurer of the Royal Society. His estate bordered on the River Wye, and their arrival coincided with the salmon-fishing season. Merton had a fine private laboratory behind the house and some interesting experiments to show, but for once Loomis was excited over something other than physics. He waded in the Wye and landed a fifteen-pound salmon.

In Paris they had a fine time visiting laboratories, among them that of Dr. Jean Saidman, who was interested in the applications of ultraviolet light in the practice of medicine. He had much to say about *Lumière Wood,* which was the name the French had given it during the war. Wood says his own name is unfortunate since in translation it frequently becomes confused with the noun. An American consul in Paris once sent a report to the State Department that the French were finding important industrial applications for the light of a mercury arc passed through a "wooden screen," his translation of *"écran de Wood."* Dr. Saidman had all sorts of electrical apparatus, including an X-ray machine with a fluoroscope. Loomis had never witnessed the action of the human stomach, and the doctor politely offered to use Wood as a guinea pig. He was given a dose of barium carbonate, after which Loomis's request was granted. Wood insisted on a mirror so that he could witness the process too.

They finally sailed for home on the *Olympic.*

Wood's sensational and exciting circus methods of presenting scientific data had a queer and beautiful repercussion in 1926. The Franklin Institute in Philadelphia decided to spon-

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sor a Christmas-week series of scientific lectures for children similar to those which Faraday had organized ninety years ago at the Royal Institution in London. Dr. Wood was invited to inaugurate the lectures with a talk on "Recreations with Radiations."

He selected from all of the optical experiments with which he was acquainted a large assortment of the most spectacular, and in particular those which could be shown by projection, for many actual experiments can be shown in operation on a large white screen with an even greater brilliancy than that of motion pictures. From these he selected the ones which young people could understand, and arranged them in such order that a logical, continued story could be built up, beginning with the simpler ideas and going on gradually to the discussion of more difficult material. In particular, he worked out a method of projecting on the screen a much longer and more brilliant spectrum than had ever been shown before, so far as he knows. It was about a foot in width and ten feet long, the rainbow colors having a high degree of purity. With this as a background he showed numerous experiments on the absorption of light by various vapors, fluids, and solids, the bright-line emission spectra of metallic arcs, and related phenomena. A host of experiments with the brilliant-colored patterns produced by polarized light and some of his early experiments with sodium were also on the program, with the demonstration of its taking fire when thrown on water, and the story of the people who were scared to death by the "man who spit fire in a puddle."

In the audience was nine-year-old Kern Dodge, grandson of Mrs. James Mapes Dodge and great-grandson of Mary Mapes Dodge, founder and long-time editor of *St. Nicholas*. The lecture had so filled this little boy with passionate joy and excitement that he went home in a sort of holy glow which set fire to his grandmother—whereupon she wrote out a check for

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$10,000 to endow the Christmas lectures for children and make them permanent.

Meanwhile, Wood's scientific work was opening up new fields for study.

In the autumn of 1927 (Wood says) I made an astonishing discovery. During the spring before, I had observed that the fluorescence of mercury vapor excited by the blue light of the mercury arc was quite strongly polarized, a condition that is recognized by the appearance of dark bands crossing the luminous patch when viewed with a Nicol prism and quartz wedge. Returning to my laboratory in the fall, I started work again, but now was unable to repeat my observations. There was no trace of polarization whatever. The setup of apparatus, lamp, mercury tube, optical parts, had not been altered. I tried to think of some slight change that I had made and forgotten, but could think of nothing except that I had turned the table around so as to get one end away from the sink. What effect could that have? Obviously none; but how about the earth's magnetic field? Fantastic idea! But I turned the table with all its load of apparatus back to its former position and lighted the mercury lamp. I looked through the polarization detector, and there were the black bands crossing the spot of green fluorescent light of the mercury vapor. Picking up a three-cornered file that was lying on the table I held it near the tube, and the dark fringes vanished. The file had been magnetized by some previous contact with a magnet, as were most of the files in my laboratory. Never before had so weak a magnetic field as that of the earth been found to affect any optical phenomenon, and work was immediately started in collaboration with Alexander Ellett, one of my best students. Our first problem, of course, was to neutralize the earth's magnetic field in the vicinity of the apparatus, which was done by a pair of wire coils carrying a carefully adjusted current. The investigation occupied us for two years, for we found still more

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interesting and complicated effects with the vapor of sodium, in which case we were dealing with the simpler phenomenon of resonance radiation, instead of with fluorescence. These results opened up a wide field of new research on the effects of magnetism on light sources, and many papers appeared by other investigators.

In the autumn of 1927 a gathering of the world's most prominent physicists met at Como, birthplace of Volta, for the celebration of the one hundredth anniversary of his death. Wood went abroad with his wife and Elizabeth.

There were solemn exercises at the tomb of Volta, receptions, boat excursions by day and night, garden parties, and motor trips to Pavia and other places.

On the last night (says Wood), there was a display of fireworks on the lake, which I have never seen equaled anywhere. It ended with a 200-yard barrage of phosphorus and magnesium bombs which exploded with terrific reports and blinding flashes of light, which were particularly effective when the great smoke clouds enveloped the flashes in a heavy veil. It is the only pyrotechnic piece I have ever seen that made cold chills run up and down my spine. It was a dramatization of war, and was terrific.

At the end of the ceremonies, the delegates went down to Rome, where other entertainment was provided, ending with a reception and afternoon tea party given by Mussolini at his Villa Corsini. They all had to be recognized by at least three members of the reception committee before being admitted.

Wood's second trip abroad with Alfred Loomis was made in 1928. They called first on Sir Oliver Lodge, who presented each of them with an autographed copy of his latest book, *Evidence of Immortality*. They next visited Sir Charles V. Boys, whom Loomis invited to go back with them in July and

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spend the summer in Tuxedo. Boys said, "Oh, I haven't been to America for twenty years, and I should like to see it now with all the changes, but I'm pretty feeble, and I tremble at the thought of such a journey. It is frightening!" His son, however, urged him to accept, and Alfred said, "All you have to do is to be in Plymouth on July 4, and I'll arrange everything else."

One of the things Loomis hoped to obtain in England was an astronomical "Shortt clock," a new instrument for improving accuracy in measurement of time. It had a "free pendulum" swinging in a vacuum in an enormous glass cylinder—and was so expensive that only five of the big, endowed observatories yet possessed one. Says Wood:

I took Loomis to Mr. Hoke-Jones, who made the clocks. His workshop was reached by climbing a dusty staircase, and there was little or no machinery in sight, but one of the wonderful clocks was standing in the corner, almost completed, which made the total production to date six. Mr. Loomis asked casually what the price of the clock was, and on being told that it was two hundred and forty pounds (about $1,200), said casually, "That's very nice. I'll take three." Mr. Jones leaned forward, as if he had not heard, and said, "I beg your pardon?" "I am ordering three," replied Mr. Loomis. "When can you have them finished? I'll write you a check in payment for the first clock now."

Mr. Jones, who up to then had the expression of one who thinks he is conversing with a maniac, became apologetic. "Oh, no," he said, "I couldn't think of having you do that, sir. Later on, when we make the delivery, will be quite time enough." But Loomis handed him the check nevertheless.

During the ensuing weeks they motored about England, visited the continent, and returned, showed motion pictures of

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the supersonic experiments before the Royal Society, went to the Derby, lunched and dined with celebrities—and then took a flying trip to Copenhagen, where they saw Niels Bohr, and then went on to Germany.

Again, at Berlin University, they showed motion pictures of their supersonic experiments, met Pringsheim, von Laue, Planck, Nernst, and most of the other famous scientists then alive in Germany. They visited the Zeiss works at Jena and the University of Göttingen, where they were invited to see a student duel. Wood was all for seeing it, but dueling was, of course, against the law, and Loomis was unwilling.

We hadn't heard from Boys meanwhile (says Wood), and it was time to be getting aboard the *Paris*. Loomis had sent Boys his steamer ticket, but we had no means of knowing whether or not his courage would hold out. As the liner slowed down at Plymouth to take on the English passengers, we looked anxiously down on the little tender, and there he was waving his hand joyfully and all ready to scramble up the gangplank, looking as relieved at finding us really on the steamer as were we at seeing him on the tender.

We had the best of everything on the boat, and the Chief Steward had a special surprise for us every night at dinner, marvels of French cooking. On the last day he announced at lunch that he had a grand surprise, something very unusual, a great luxury! *"Epatant!* Only wait and see." Sure enough, after the soup and fish a wagon was solemnly rolled up to our table, bearing a great silver dish covered with an oval silver dome. The Chief Steward was in attendance. He rubbed his hands together and smiled at us, and then lifted the cover, displaying in all its stark nakedness a huge shapeless mass of shivering, steaming corned beef, garnished with cabbage and cauliflower and whatever else goes with this, my pet abomination, a New England boiled dinner.

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Back in America, they learned that Professor James Franck, Nobel prize winner, was coming over in January to give lectures at various universities. Wood suggested to Loomis that he hold a congress of physicists in his Tuxedo Park laboratory in Franck's honor. Franck accepted and the meeting was held in the library, a room of cathedral-like proportions, with stained-glass windows. Franck gave his first lecture in America there. Wood, Loomis, and others made subsequent addresses. The visiting American physicists were conducted through the laboratory and shown the supersonic and other experiments. The congress in this palace of science proved such a success that it was repeated the following year.

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CHAPTER SIXTEEN

How Wood Solved the Mystery of King Tutankhamen's Purple Gold—with the Aid of His Wife's Nail Polish

In the weird Wood guest book at East Hampton is a drawing made by Ambrose Lansing, curator of Egyptology at the Metropolitan Museum in New York. It is only slightly Egyptian. It is a burlesque of Wood's own Animal Analogues, and is entitled "The Wood and the Woodchuck." It depicts the woodchuck stealing lettuce from a cold frame not unlike a museum case, and the Wood similarly engaged in purloining the famous purple-gold sequins of King Tutankhamen from their case in the Cairo Museum.

"A joke's a joke," said Dr. Wood, "but after all we didn't *steal* the purple sequins. You might say we abstracted them with the connivance of the Curator. You might even say, if it gives you more fun to put me always in the worst possible light, that we surreptitiously abstracted them, but—"

"Did Curator Engelbach of the Cairo Museum say, or didn't he," I interrupted, " 'For God's sake keep it secret until you get out of the country, and on no account let Howard Carter know'?"

"I don't think he said 'for God's sake,' " Dr. Wood replied, "and the only reason we didn't want Carter to know was that we didn't want to enrage him. After all, he was the one who had dug the stuff up. He fancied himself as a sort of sole execu-

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tor and publicity agent for King Tut, and had never tolerated others cutting in on it."

"All right," I agreed, "you didn't purloin them. I'll let you tell in your own way in a minute exactly how you did obtain their—shall we call it?—temporary legitimate possession."

Dr. Wood had become interested in the purple gold while on a visit to Egypt in 1931 with Mrs. Wood, traveling with Ambrose Lansing and his wife, Caroline, who were going to Cairo to superintend excavations at Lisht. It presented a mystery which Egyptologists, metallurgic chemists, and modern goldsmiths had been unable to solve. They hadn't even been able to agree on the nature of the problem. A dispute had arisen since the discovery as to whether the purple gold was the product of an art known to King Tutankhamen's goldsmith and subsequently lost for over three thousand years or was due to chemical changes resulting from long burial.

When Wood heard all this and saw the actual ornaments, all rose and red and purple, his scientific detective instincts were challenged, and I suspect also that his ubiquitous cat curiosity was involved in the subsequent events for more than a little. The problem, as a matter of fact, was a fascinating one for anybody. In the meantime Lansing had arranged with the authorities that the Woods were to receive all the privileges extended to archaeologists. Many of the smaller gold ornaments from the tomb were covered with a rose-purple film, quite unlike anything that had ever been observed on gold jewelry or coins either ancient or modern.

Wood leaned almost immediately to the theory that the purple sequins were the result of art rather than chemical accident. He noted the resemblance of the colors to those of certain gold films which he had prepared many years before when engaged in the study of the optical properties of very finely divided metallic granules, and felt sure that they had been produced at the time of manufacture, for on one of the king's slippers small purple-gold rosettes and yellow-gold bars

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had been sewn in alternation, making a color pattern. There was, however, the possibility that the rosettes and bars had been made by different goldsmiths, with metal from different localities, one sample containing an impurity which slowly oxidized during the centuries, forming the purple film.

The objects on which the colored film appeared were small ornaments exclusively, sequins—some in the form of flowers from 1.5 to 2 cm. in diameter and others circular concave disks—which ornamented the ceremonial robe of the king, and a number of pendants and other head ornaments, on some of which the colors were extremely brilliant, ranging from a rich red to purple and violet.

Wood made a careful examination of the gold ornaments from other tombs displayed in the Cairo Museum, but found nothing resembling the Tutankhamen gold with the exception of a queen's crown from the next dynasty, which was decorated with gold flowers showing the purple film in many places. This made it seem possible that the secret of the coloring process had been handed down from father to son, but had finally been lost.

So this all made a pretty problem. Said Wood to himself and to Lansing, and to their friend A. Lucas, who was British Chief Chemist for the Department of Antiquities in Egypt, "I believe I could rediscover the secret—if I could get hold of some of the ornaments."

Lucas was for it, but it wasn't going to be easy. Howard Carter wasn't going to be eager to lend them to an itinerant American professor who wasn't even an Egyptologist to play with. And they were all locked up and screwed down in their museum case in Cairo.

"The only thing we can do," said Lucas, "is to get the consent of the Curator."

When the plot was disclosed to Curator Engelbach, he agreed in the interest of science, but concurred emphatically—with or without the "for God's sake"—when Lucas said, "We'll

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MOONSHINE: One of the photographs Wood faked for illustrating *The Moon-Maker*, the pseudo-scientific "thriller" on which he and Arthur Train collaborated. The "flying ring" is taking off from the surface of the moon.

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MAJOR WOOD: Wood is testing the "flash telescope," which he originally constructed from an old piece of stovepipe and other discarded parts, and which was the first device offered by the Science and Research Division actually put into production for overseas use in the A.E.F.

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have to keep this secret. No sense ever to let Howard Carter know—unless you succeed with the experiments."

It wasn't merely Howard Carter's private vanity. If the government learned that Wood was trying to take out any of the sequins, he would be searched at the customs house until they were recovered, and Carter would raise public hell—not about "purloining," but about the proposed unauthorized investigation.

What they did next, I'm letting Wood tell in his own way.

After Lucas had persuaded the Curator, the three of us went to the museum hall accompanied by two uniformed guards who had two separate sets of keys. While popeyed tourists stood around, they opened six separate padlocks and were then compelled to take out about a dozen screws which held down the glass. When the case was opened the Curator whispered to me to pick out what I wanted. I began picking sequins, with continual side glances at the Curator, watching for raised eyebrows. At the eighth, I saw symptoms and said, "Thank you very much, these will suffice." I had been picking them out with my right hand and holding them in my left. The Curator said sternly and aloud, doubtless to reassure the popeyed tourists or perhaps his own guards, "Now give them to me." He was a sleight-of-hand artist and slipped them back to me before we left the museum.

The archconspirator had scarcely returned to his hotel when a note was brought to him—from Howard Carter! It turned out, however, as coincidences happily often do, to be merely an invitation to visit the great Egyptologist in his laboratory headquarters in one of the old tombs, in the Valley of the Kings. Wood bearded the lion, and says, "I felt like the boy who'd almost been caught stealing the apples . . . but at the same time felt a temptation to tell him I had the sequins."

How Wood found the lost secret of the purple gold, begin-

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ning there in Cairo with his wife's nail polish and ending in the Johns Hopkins laboratories with a series of experiments as strange as any you'll find in fictional scientific detection, is today a brilliant page in the history of Egyptology and of chemical-physical research. He not only rediscovered the ancient method and proved that the coloring was no accident due to chemical changes, burial, and time, but succeeded in reproducing, by a finally simple technique such as might easily have been known to goldsmiths three thousand years ago, all the gorgeous colors, ranging from roseate dawn pink through rich red, purple, and violet. Here in his own clear words is the story step by step.

My first problem (he explains) was to ascertain whether the colors were simple "interference" effects of thin films (soap-bubble colors) or due to some "resonance" action of minute particles covering the gold surface. This was purely a problem in physical optics. Since interference requires the cooperation of two streams of light reflected from the opposed surfaces of a thin film, the first step in the study appeared to be to destroy the reflection from the outer surface by covering it with a transparent varnish. This experiment I tried in Cairo, employing my wife's nail polish, the only available material of the desired nature. The color was not destroyed, as it would have been in the case of an interference color, and after the celluloid had become dry, I found that it could be peeled off, carrying the film with it and leaving the underlying gold bright yellow. The film, however, now showed no color, either by transmitted or reflected light. This was as far as I could go at the time, but on my return to my laboratory in Baltimore I deposited metallic gold on the back of the film by cathodic sputtering and found that the purple reflection was restored. These two experiments appeared to show conclusively that we were dealing with something more complicated than simple thin film interference.

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The next step was to ascertain the nature of the film. This was done by placing a bit of the celluloid film carrying the film from the sequin between two electrodes of pure gold and photographing the spectrum of a very brief spark discharge. Iron lines were found in the spectrum. A purple sequin was then hung on a very fine glass thread between the poles of an electromagnet, and when the current was turned on, it was drawn to one of the pole pieces. One of the yellow bars from the slipper was thrown out of the magnetic field, showing that it contained no iron, while one of the small purple rosettes was attracted. These two specimens were returned to the museum, as they were needed for the reconstruction of the slipper. They had served their purpose, however, in showing that the purple rosettes contained iron, while the yellow bars were free from it. It was now necessary to find out how the film, presumably iron oxide, had been formed, and whether it was intentionally produced or was an accidental patina resulting from time.

I prepared an alloy of pure gold and a very small fraction of 1 per cent of iron, hammered the bead into the form of a disk, and heated it over a very minute flame. At a temperature a little below a dull red heat a beautiful purple film formed, matching the color of the sequins almost exactly. As I could not ascertain the effect of three thousand years of exposure to the air on one of my alloy plates, I was obliged to look for other evidence that the color was produced by the heat process. I removed the purple film from a small piece of one of the sequins by nitromuriatic acid and examined the gold with the microscope. The surface had been etched by the acid and showed a very marked crystalline structure. A similar treatment of one of my replicas revealed the same crystalline structure, which was not shown by specimens which had not been heated to a high temperature after the hammering process. Pure gold rolled into a thin plate between steel rollers shows only very minute crystals when etched, but if heated shows

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crystals of exactly the same size and character as those found in the Egyptian sequins. This was proof number one that the sequins had been heated *after* their manufacture.

Proof number two came as a result of an investigation of another surface characteristic of the sequins, the invariable presence of minute metal globules of gold which stood up in high relief on both sides of the sequins. Obviously these must have been formed after the ornaments had been hammered or rolled into shape, and one or two had the form of minute mushroom buds, a globule supported on a short stem. This suggested that they had been exuded or excreted by the metal, by a process similar to that which occurs when a silver bead is heated on charcoal by the blowpipe flame, the phenomenon referred to as the "spitting of silver." It results from the liberation of dissolved gas at the moment of solidification of the globule. I was unable to find any allusion to a similar performance by gold and for some time was unable to produce the globules on my replicas.

The solution of the problem came in a rather fantastic way. I had made spark spectra of the purple sequins and found practically no lines save those of gold and iron, the latter being quite strong. A more careful scrutiny revealed a few very faint lines which could not be attributed to either metal, and two of these I attributed to arsenic. I next heated a small fragment of one of the sequins in a small tube of fused quartz to a temperature considerably above the melting-point of the gold in a very slow stream of hydrogen, and found a deposit on the wall of the tube beyond the heated portion, a yellow and a black ring, the latter on the side away from the gold. I therefore suspected the presence of sulphur and arsenic, and native sulphide of arsenic (the yellow pigment orpiment) was in fact imported into Egypt during the Eighteenth Dynasty and used in tomb decorations. This suggested that the royal goldsmith had perhaps tried the experiment of fusing gold with the yellow pigment in the hope of improving the color

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or of getting more gold. I wrote to Mr. Lucas asking for a few minute scrapings of this material, and he sent me some small lumps that had been found in a cloth bag in the tomb of Tutankhamen. I fused a small speck of this substance wrapped up in a pellet of thin gold plate, and as the fused globule solidified it "spit" out a small globule exactly as silver does. But a thin plate hammered from this globule and then heated showed no trace of further "spitting."

It was now obvious that the gold and orpiment would have to be melted together and solidified under pressure to obtain a specimen that would "spit" after being fashioned into a plate by hammering or rolling. I accordingly heated the two in a small sealed tube of fused quartz, melting the gold down to a round globule. Some of the sulphur and arsenic was liberated as vapor under pressure and glowed bright red in the non-luminous tube (for quartz radiates practically no light even at very high temperatures). After cooling, the tube was opened and a plate hammered and rolled from the globule. When heated to a dull red heat the plate grew a marvelous crop of metal mushrooms.

This suggested that the necessary pressure required for keeping sufficient arsenic and sulphur in the gold to produce "spitting" may have resulted from the fusion of a considerable mass in a crucible, for we know from the bas-reliefs at Saqqara that the Egyptians used furnaces operated by air blasts from human lungs. But there was another and more probable alternative, namely, that the sequins had been fashioned from native gold nuggets which contained a trace of iron as an impurity. These, having been originally formed deep in the earth and under pressure, might easily contain sulphides, arsenates, or similar gas-producing compounds in sufficient quantity to produce the small amount of "spitting" shown by the sequins.

A number of plates were therefore hammered from small nuggets of native gold from various localities, and most of them showed the excretion of minute globules when heated

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to a dull red. None of these showed any trace of the purple film, however, and I wrote to Mr. Lucas asking for specimens of native Egyptian gold. The single specimen which he sent gave globules, but no purple film. This gold was, however, embedded in quartz, and unsuitable for immediate fashioning into ornaments. Alluvial gold may very probably have been imported from Abyssinia, where the placer deposits are still worked, and it would be extremely interesting to see whether the purple color would appear on plates hammered from nuggets from this or from other possible sources of ancient Egyptian gold. On the whole, I favored the theory that the sequins were hammered from nuggets of native gold containing a trace of iron, one of which was accidentally dropped into a fire, or perhaps heated for annealing, with the resulting discovery of the purple color.

A complete survey of the gold deposits of Abyssinia was under way in 1932, and I wrote to Mr. E. A. Colson, president of the Bank of Addis Ababa, asking for small nuggets from different localities. These he mailed to me from time to time, and all yielded globules, but none the purple film. I had explained to him that should a sample ever be found containing iron it might prove to be a valuable clue in locating the rich deposits worked in ancient times. Mussolini, however, stopped the game just as it was getting under way, and Mr. Colson died shortly after.

Some of the sequins made by Dr. Wood are now in the Cairo Museum along with the originals. His solution of the mystery is embalmed in the British *Journal of Egyptian Archaeology* and in the archives of the Egypt Exploration Society.

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CHAPTER SEVENTEEN

Wood as a Debunker of Scientific Cranks and Frauds—and His War with the Mediums

DR. WOOD has had a long career, dating back beyond the days of Blondlot's "N rays" and the American visit of Eusapia Palladino, in the exposure of frauds and delusions, whether emanating from supposedly scientific laboratories or from mediumistic cabinets.

In the investigation of doubtful phenomena, he is neither academic nor tame nor conventional. In the case of the famous "N ray," he made a trip to the University of Nancy, and dramatically exposed the most extraordinary scientific delusion of modern times. When Grindell Matthews came over from England with his "death ray" and was trying to induce our government to buy it for the navy, the Associated Press asked Wood to look into it. Wood "looked into it" and gave the press a scathing broadside in which he compared Matthews, "whether self-deluded or not," to "promotors who try to sell Brooklyn bridges to innocent bystanders."

In the Palladino investigation, in which he was a member of the committee appointed under the auspices of the *Scientific American,* he employed X rays and also an ingenious "Venetian-blind" arrangement by which the floor of the medium's cabinet was illuminated without her knowledge. In the later case of Margery, the Harvard-investigated medium, he seized hold of and pinched—her ectoplasm!

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In Wood's opinion, these scientific leaders up false alleys divide sharply into two categories—self-deluded cranks and downright frauds. The former honestly imagine they have an idea and can make a fortune for themselves and others if they get the backing. The impostors usually set up a tiny but elaborate apparatus worked by trickery, with the hope of impressing some gullible capitalist who might advance them a lot of money to carry out the "idea" on a grander scale. Both categories are old as the hills and perennial as the daisies. Last summer Wood was being urged to investigate a man who claimed he could run a farm tractor by wireless power, with waves from a station a hundred miles distant. He also, of course, had a "death ray." They always have "death rays." He had a promotor who'd been pestering the great physicist, and who insisted he had seen a duck brought down from an elevation of eight hundred feet.

"Investigating such people," said Wood, "is often amusing, but generally a waste of time. The bigger, more serious cases are different."

Here is Wood's own account of what was probably the greatest scientific delusion of our time.

In the late autumn of 1903, Professor R. Blondlot, head of the Department of Physics at the University of Nancy, member of the French Academy, and widely known as an investigator, announced the discovery of a new ray, which he called N ray, with properties far transcending those of the X rays. Reading of his remarkable experiments with these rays in the *Comptes rendus* of the Academy, the leading scientific journal of France, I attempted to repeat his observations, but failed to confirm them after wasting a whole morning. According to Blondlot, the rays were given off spontaneously by many metals. A piece of paper, very feebly illuminated, could be used as a detector, for, wonder of wonders, when the N rays

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fell upon the eye they increased its ability to see objects in a nearly dark room.

The flame of discovery kindled by Blondlot was now burning brightly, and fuel was added by a score of other investigators. Twelve papers had appeared in the *Comptes rendus* before the year was out. A. Charpentier, famous for his fantastic experiments on hypnotism, claimed that N rays were given off by muscle, nerves, and the brain, and his incredible claims were published in the *Comptes,* sponsored by the great Arsonval, France's foremost authority on electricity and magnetism.

Blondlot next announced that he had constructed a spectroscope with aluminum lenses and a prism of the same metal, and found a spectrum of lines separated by dark intervals, showing that there were N rays of different refrangibility and wave length. He measured the wave lengths. The flame of N-ray research was now a conflagration. Jean Becquerel, son of Henri Becquerel, whose discovery of the rays from uranium had laid the foundation for the discovery of radium by the Curies, claimed that N rays could be transmitted over a wire, just as light can be transmitted along the inside of a bent glass rod by internal reflection. One end of a wire near the faintly luminous detector caused variation of its intensity as the other end, some meters away, was passed over the skull of a living person. If the subject was anesthetized with ether, the N rays from the brain first increased and then decreased as the sleep deepened. He claimed that metals could be anesthetized with ether, chloroform, or alcohol, in which condition they ceased to emit or transmit the rays. Biologists, physiologists, psychologists, chemists, botanists, and geologists climbed on the band wagon. The nerve centers of the spinal cord in their relation to disease and previous surgical operations were studied by the N rays which they emitted. The rays were given off by growing plants, vegetables, and even by a human corpse. Charpentier found the senses of hearing and smell were in-

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creased by N rays as well as the sense of sight. A tuning fork in vibration gave a powerful N ray. By early summer Blondlot had published twenty papers, Charpentier twenty, and J. Becquerel ten, all describing new properties and sources of the rays.

Nearly one hundred papers on N rays were published in the *Comptes rendus* in the first half of the year 1904. The N ray was polarized, magnetized, hypnotized, and tortured in all of the ways that had forced confessions from light rays—but only Frenchmen could observe the phenomena. Scientists in all other countries were frankly skeptical, in fact ridiculed these fantastic impossibilities. But the French Academy stamped Blondlot's work with its approval by awarding him the Lalande prize of 20,000 francs and its gold medal "for the discovery of the N rays."

During that summer we were at Beg-Meil, in Brittany, and I was out of touch with the scientific high jinks in Nancy, but in September I went over to Cambridge for the meeting of the British Association for the Advancement of Science. After the meeting some of us got together for a discussion of what was to be done about the N rays. Of our group, Professor Rubens of Berlin, with whom I had come in close contact while a student, was most outspoken in his denunciation. He felt particularly aggrieved because the Kaiser had commanded him to come to Potsdam and demonstrate the rays. After wasting two weeks in vain efforts to duplicate the Frenchman's experiments, he was greatly embarrassed by having to confess to the Kaiser his failure. Turning to me he said, "Professor Wood, will you not go to Nancy immediately and test the experiments that are going on there?" "Yes, yes," said all of the Englishmen, "that's the idea, go ahead." I suggested that Rubens go, as he was the chief victim, but he said that Blondlot had been most polite in answering his many letters asking for more detailed information, and it would not look

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well if he undertook to expose him. "Besides," he added, "you are an American, and you Americans can do *anything*. . . ."

So I visited Nancy before rejoining my family in Paris, meeting Blondlot by appointment at his laboratory in the early evening. He spoke no English, and I elected German as our means of communication, as I wanted him to feel free to speak confidentially to his assistant, who was apparently a sort of high-class laboratory janitor.

He first showed me a card on which some circles had been painted in luminous paint. He turned down the gas light and called my attention to their increased luminosity when the N ray was turned on. I said that I saw no change. He said that was because my eyes were not sensitive enough, so that proved nothing. I asked him if I could move an opaque lead screen in and out of the path of the rays while he called out the fluctuations of the screen. He was almost 100 per cent wrong and called out fluctuations when I made no movement at all, and that proved a lot, but I held my tongue. He then showed me the dimly lighted clock, and tried to convince me that he could see the hands when he held a large flat file just above his eyes. I asked if I could hold the file, for I had noticed a flat wooden ruler on his desk, and remembered that wood was one of the few substances that *never* emitted N rays. He agreed to this, and I felt around in the dark for the ruler and held it in front of his face. Oh, yes, he could see the hands perfectly. This also proved something.

But the crucial and most exciting test was now to come. Accompanied by the assistant, who by this time was casting rather hostile glances at me, we went into the room where the spectroscope with the aluminum lenses and prism was installed. In place of an eyepiece, this instrument had a vertical thread, painted with luminous paint, which could be moved along in the region where the N-ray spectrum was supposed to be by turning a wheel having graduations and numerals on its rim. This wheel turned a horizontal screw with a movable nut on

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which the thread was mounted. Blondlot took a seat in front of the instrument and slowly turned the wheel. The thread was supposed to brighten as it crossed the invisible lines of the N-ray spectrum. He read off the numbers on the graduated scale for a number of the lines, by the light of a small, dark-room, red lantern. This experiment had convinced a number of skeptical visitors, as he could repeat his measurements in their presence, always getting the same numbers. He claimed that a movement of the thread of 0.1 mm. was sufficient to change the luminosity, and when I said that seemed impossible, as the slit of the spectroscope was 2 mm. wide, he said that was one of the inexplicable properties of the N rays. I asked him to repeat his measurements, and reached over in the dark and lifted the aluminum prism from the spectroscope. He turned the wheel again, reading off the same numbers as before. I put the prism back before the lights were turned up, and Blondlot told his assistant that his eyes were tired. The assistant had evidently become suspicious, and asked Blondlot to let him repeat the reading for me. Before he turned down the light I had noticed that he placed the prism very exactly on its little round support, with two of its corners exactly on the rim of the metal disk. As soon as the light was lowered, I moved over towards the prism, with audible footsteps, but *I did not touch the prism.* The assistant commenced to turn the wheel, and suddenly said hurriedly to Blondlot in French, "I see nothing; there is no spectrum. I think the American has made some *dérangement.*" Whereupon he immediately turned up the gas and went over and examined the prism carefully. He glared at me, but I gave no indication of my reactions. This ended the séance, and I caught the night train for Paris.

Next morning I sent off a letter to *Nature,* London's scientific weekly, giving a full account of my findings, not, however, mentioning the double-crossing incident at the end of the evening and merely locating the laboratory as "one in which

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most of the N-ray experiments had been carried on." *La Revue scientifique,* France's weekly semipopular scientific journal, published a translation of my letter and started an *Enquête,* or inquiry, asking French scientists to express their opinions as to the reality of the N rays. About forty letters were published in the succeeding numbers, only a half dozen backing Blondlot. The most scathing was one by Le Bel, who said, "What a spectacle for French science when one of its distinguished savants measures the position of the spectrum lines, while the prism reposes in the pocket of his American colleague!"

Only two papers on N rays appeared in the *Comptes rendus* after this. They may have been delayed in the mail. The Academy at its annual meeting in December, when the prize and medal were presented, announced the award as given to Blondlot "for his life work, taken as a whole."

The tragic exposure eventually led to Blondlot's madness and death. He was a great man, utterly sincere, who had "gone off the deep end," perhaps through some form of self-hypnotism or overstimulated retinal imagination due to years of staring in the dark. What Wood had done, reluctantly but with scientific ruthlessness, had been the *coup de grâce.*

This climax was summarized by A. A. Campbell Swinton, F.R.S., in the *Westminster Gazette:*

> . . . the highest scientific tribunal in France had made its award and all apparently went well till an American Professor of Physics —R. W. Wood, of Baltimore, now a foreign member of the Royal Society of London—exploded completely and forever the whole discovery by showing to Blondlot that he *continued to see the spectrum,* when no spectrum could possibly exist there, if indeed there ever had been one!

Toward outright scientific frauds and fakers, Wood is scornful and merciless, never feeling any sadness or depression over their exposure, but rather a savage and amused elation. One

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night in Baltimore, after a dinner, he told me and a couple of friends a number of his adventures in this field.

Some years ago, I was asked by Mr. Bernard Baker, president of the Atlantic Transport Line and trustee of the university, to come down to his office and look into the apparatus of a man whose experiments he was financing. It was a scheme for transmitting speech and signals under water. The man claimed he'd discovered a new chemical which was sensitive to sound. Mr. Baker had given him a large room in his office building to use as a laboratory, and I was taken there. He had a large table covered with a hodgepodge of pseudoscientific instruments. There was a dome-shaped bell with eight small pendulums hanging around it, touching its rim. Several parts of a typewriter were included in the setup! The whole thing, on the face of it, was perfectly preposterous, a collection of junk connected by wires. The inventor said his chemical was so sensitive to sound that it was decomposed by noises which the human ear could not possibly hear. I asked him how he could make it, if it was so sensitive, and he said he had to prepare it undersea, in a diving bell! I advised Mr. Baker to kick the man out of his office—which he did a day or two later.

On another occasion I was taken to the roof of a downtown office building to see a demonstration by an inventor who claimed he'd found a method of getting power out of the atmosphere. His table was covered with electric motors, a small toy railroad with an electric locomotive, and other little gadgets run by electricity. At one end of the table a pole ran up in the air, with fifteen or twenty brass points radiating from it. These, he said, gathered the power from the atmosphere, which came down the wire and operated the toys and gadgets on the table. There was a crowd of newspaper reporters and one or two men from whom he was trying to get money. There were several boxes under the table, partly covered by burlap, and one

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box which was completely covered. Nobody had paid any attention to this part of the "exhibit," and I pulled the burlap from the box that was completely covered, disclosing a big storage battery with two wires leading up to the top of the table, along the inside of one of the legs! He cleared out of the hotel without paying his bill, carrying all of his apparatus with him.

"They used to tar and feather 'em when they came like that out West," interpolated Leslie Hohman, the psychiatrist. "There's a difference between the deluded crank and the deliberate faker. In which class, by the way, was that Paris inventor who did monkey tricks with electric light bulbs, and got into the semiscientific journals for a while? He was going to revolutionize all our lighting systems, as I recall."

Well, I never quite knew (replied Wood). As a matter of fact I don't know yet whether he was trying to bribe—or befuddle—me with champagne. But whether crook or crackpot, he was an amusing fellow. He claimed he could reduce the amount of current required for illumination to a fifth of what the bulbs use now. I happened to cross over that summer with the New York capitalist who was planning to sink $20,000 in the experiments, and promised to investigate the phenomenon. I warned him not to disclose my identity but to say merely that I was a Mr. Wood, a friend of his, who was also interested in the invention. About a week after I'd arrived in Paris, there came a phone call inviting me to the inventor's house and laboratories. His idea was to feed short intermittent pulses of current into the lamps in succession. He used double the voltage for which the lamps were rated, shooting the flashes of current from one lamp to another. He was innocent as a babe of any suspicion I was a physicist. He supposed I was just another American business man who knew all about dollars

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but nothing about dynamos. He assured me solemnly that light produced from lamps by his method had very peculiar properties resembling those of X rays, as they could penetrate flesh so that you could see the bones! He held one in his clenched fist and tried to make me think I was "seeing the bones"!

Presently he illuminated three lamps arranged on a rotating wheel at the center of the ceiling. Up to then I had listened openmouthed to his fantastic claims, as if bewildered and entranced, but now I asked for a hand mirror which was presently found for me by his assistant. I studied the reflection of the whirling lamps in the mirror and waggled the mirror rapidly to and fro, muttering some gibberish to myself about a "luminous sine-wave curve of variable intensity."

"Ah" and "ah" again exclaimed the inventor, "Monsieur then comprehends something of the physik?" I was tired of the nonsense, though it had been amusing, so I said, "Yes, I am R. W. Wood of Johns Hopkins University."

He hesitated for a perceptible second, then leaped on me in ecstasy, shaking my hand in seeming delight. "Oh, but this is for me a very great honor! Wait and you shall see." Whereupon he darted out of the room, returning in a moment with a copy of my *Physical Optics*. Then, believe it or not as Ripley says, he turned page after page (of my own book, Lord help us!) with marked paragraphs, and exclaimed, "Here you see the proof! Here and here and here! And now we shall drink to your health. . . ." He pushed a bell, gave his instructions, and presently the butler appeared with a bottle of champagne. The circus had been well worth an entire morning lost—but not worth my friend's $20,000.

Allen W. Harris of the Baltimore *Sun,* who was pouring us all another drop of whisky, said, "Maybe he thought if you'd go in cahoots with him, you could raise it to a million."

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SCIENTIFIC DETECTIVE: Wood examines a bomb fragment while Lieutenant Itzel looks on, during the investigation of the Brady bomb mystery.

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CELEBRITIES: Wood, Max Planck, and Albert Einstein in the front row of a scientific lecture in Berlin in 1931. It was after this meeting that Wood tested the party guests with the bitter-tasteless powder.

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The most fantastic piece of electro-medical hokum ever brought to his attention, says Wood, was the recent "discovery" of a method of sending the curative properties of sulfanilamide over a copper wire to an aluminum plate on which bottles of distilled water were standing. At the end of a half hour the water in each bottle was supposed to become highly charged with the germicidal properties of the drug. This charged water, the inventor claimed, could then be used internally or by intravenous injections . . . "with results equal to those produced by solution of the sulfanilamide itself in water." And he claimed that it had made "a favorable impression" on the director of the Chemical Foundation in New York!

The inventor of the discovery was asked to demonstrate it before a committee at Johns Hopkins Medical School. Dr. Perrin Long, who has been largely responsible for putting sulfanilamide on the map, persuaded Wood to help debunk the demonstration.

The inventor in this case was a true "screw ball" who believed he would be a benefactor of mankind. He was not seeking the Foundation's money. He had plenty of his own.

"It was funny and crazy," says Wood, "but pathetic."

When Eusapia Palladino visited America thirty years ago, many celebrated scientists, in addition to the psychologists and psychic-research crowd, had begun to take an active and inquisitive interest in mediums. The *Scientific American* sponsored and financed a committee to investigate the famous Italian medium, while the newspapers reported that Mr. Edison was working on a sensitized electrical apparatus which might supersede ouija boards and planchettes in the séance room. Wood took his pen in hand and gave birth to the following ode, which he entitled "The Edison *Specter*-Scope"!

> "Of mediums I trust not one,"
> Said Thomas Alva Edison.

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"The planchette plays pernicious pranks,
The table tips and turns and twanks.
With mediums I cannot grope—
I shall invent a specter-scope!"

He called his helpers one by one,
Did Thomas Alva Edison.
They took some wheels, a spring, a cam,
Attached them to a diaphragm,
Arranged a lens within a coil,
A red-hot strip of platinum foil.
And when at last the thing was done
They put it in a vacuum.

"With your ideas I sure agree,"
Said Mr. Thomas Alva E——.
"To show themselves through this, the Shades
Will all come trooping up from Hades.
For this old Noah will leave his Ark
And travel down to Menlo Park.
Put down the shades, shut out the sun,"
Said Thomas Alva Edison.
"And let the Pianola play
Turn on the ultraviolet ray
And watch old Thomas cramp the style
Of Oliver Lodge and Conan Doyle."

Wood was never much interested in the purely psychic pretensions of the mediums, but he had an inordinate curiosity concerning the floating trumpets, tambourines, ectoplasmic excrescences which at that time were, and frequently still are, a part of the *mise en scène* which heralds the approach of the dear departed.

When Palladino was brought to New York, Dr. Wood was asked to serve on the American committee. She was primarily a physical medium—and physics was his meat. The physical medium doesn't produce messages from the dead, but gives séances in which objects at a distance are moved, breezes blow, phosphorescent lights appear, tables rise in the air, impressions of hands are produced in wet clay, while musical instruments

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are played at a distance from the medium, who is supposed to be either securely tied or held firmly in the grasp of spectators —or both.

The Palladino sittings (says Wood) were held in the physical laboratory of Columbia University. The cabinet had been built into the doorway in Professor Hallock's office in such a way that it jutted back into the apparatus room adjoining. They had cut a hole through the brick wall which separated the two rooms, close to the floor so that an observer could lie in the apparatus room and watch what was going on under the table, or as much as could be seen in the dim light. The cabinet contained a table on which the usual pieces of apparatus reposed, a tambourine, a bunch of flowers, and one or two other things that I have forgotten. Eusapia sat in a chair with her back to the curtain, her hands resting on a small wooden table, around which the other observers were gathered. Palladino was known to cheat whenever she was given an opportunity, and was frequently caught doing so. I convinced myself very early in the series of sittings that *all* the phenomena were fraud. I was puzzled by the blowing out of the curtains, with all the windows closed and the doors locked. Münsterberg, who succeeded Professor James at Harvard, attended some sittings later on, and explained that the curtain had been blown out by a jet of air from a rubber bulb that she had in her hand. Objects were "brought" out from the cabinet and appeared on the table in front of Palladino when her hands and feet were supposed to be held, and I was anxious to see what the instrument was that had reached back through the curtain. I decided it could be seen if the floor of the cabinet were feebly illuminated. An observer lying on the top of an apparatus case in the next room, looking down through a hole in the top of the cabinet could see whether an arm or hand reached back for the tambourine, or whether the trick was done with some mechanical appliance. It was necessary, how-

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ever, to arrange this so that Palladino would not see the light on the floor, as she had a way of pushing back the curtain and looking in occasionally. I accomplished this by making a wooden grill of thin, vertical slats, like a Venetian blind, painted black, which covered the floor under the cabinet. By propping one corner of the cabinet up for a quarter of an inch with a little wedge and placing an electric light to one side of the cabinet, the rays entered through the crack and spread over the floor, producing a feeble illumination. I could see this from above, looking down through the hole in the top, and between the slats, which, however, obscured the luminosity entirely from the eyes of Palladino, who was sitting at one side. . . .

And, sure enough, at the very next sitting, peering down from my recumbent hiding-place above the cabinet, I could see a distinct black outline like a shadow silhouetted against the luminous floor. It was a long pointed triangle, and it poked around among the flowers and the tambourine but failed to bring anything out through the curtain. Palladino had an uncanny intuition whenever anything had been planned to trap her. She may have got a glimpse of the wooden grill on the floor that evening, which made her suspicious, even if she did not know the purpose for which it had been placed there. I finally decided to use X rays, placing a powerful tube on one side of the cabinet, and a fluorescent screen about four feet square on the opposite side. We tried this out before the sitting and it worked beautifully. Anyone reaching back through the curtain to the table could be at once detected and the observer in the dark room behind would see the bones of the hand and arm, or the projecting rod if she used one, as a sharp, black shadow on the fluorescent screen. We all had high hopes of this equipment, but when Palladino arrived she said she was "not feeling well" that evening and would not hold a sitting.

If Wood was a ruthless expert in setting scientific bear traps, Palladino was a "bear" at smelling them out and evading them.

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She'd had her toes pinched occasionally, and was wary. She was "feeling no better" the next day, or the next, or on any day thereafter, so far as the American committee was concerned, if Wood was on it. The record shows she refused ever to hold another sitting for them.

Wood was, and still is, an admirer of hers. Convinced that so far as any supernatural or even supernormal power was concerned, it was all a fraud, he considers her to have been the greatest performer of her time, and the greatest, perhaps, in the history of the world. He had profound respect for her ability—and apparently she also had for his.

He has, on the contrary, an impatient, biting scorn for all "psychic" and spiritualist mediums, whether amateur or professional, who claim communion with the dead—and has taken a fiendish delight in skinning a lot of them. He got out of patience some years ago with a doctor acquaintance who had suddenly discovered wonderful psychic gifts in his wife while fiddling with the ouija board. This doctor usually had a finger or two of his own on the board while it was scrambling to and fro along the alphabet, and later when they graduated to the planchette, he still kept his own fingers on the little table. Presently a furor was created by the announcement that the doctor's wife had pulled a poem out of the infinite—in an ancient, unknown language. Taken to an authority on obscure ancient dialects, it proved to be in Old Icelandic. It was the copy of an actual poem which had been written centuries ago, the original being in the British Museum. Later Wood learned, however, that reproductions had appeared in a printed journal as late as the eighteenth century—and he smelt a very smelly rat. There was no way, however, to smoke the rat out of its hole. You couldn't prove that sort of thing. You couldn't prove that the doting doctor husband had copied the poem and simply reproduced it via his wife and her planchette. But later they made the mistake of inviting Wood to one of their spirit hunts, and offered to raise a spook for him. The host said:

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"Is there anyone whom you knew well and who has died quite recently—preferably one who has 'gone over' no longer than a year or two ago?"

"Yes," said Wood, "I'd very much like something from Lord Rayleigh." Lord Rayleigh, the great British physicist, had died just a little while before. Wood wanted no wishy-washy wraiths. He asked for a tough one.

They put their hands on the board, and the host said repeatedly, "Lord Rayleigh, are you with us?" Presently the planchette wrote "Yes," and the host said to Wood, "Have you any question to ask by which he can establish his identity?"

"Yes, I should like any remembrance he has of Terling." Terling was the name of Lord Rayleigh's country place. Presently the planchette began to tremble, and soon neatly wrote, *"The ring of the stones on the swept ice."*

The rat was in the bag! The literarily gifted spook-summoner had tangled the word with "curling," the Scotch game in which heavy flat stones are skidded over ice which has been swept clean with a broom. Wood was a guest, so he contained his contempt, and bade the doctor and his wife good night.

Sometimes these sources of seemingly spirit-inspired knowledge are not easy to trace. After Wood had begun to learn most of the tricks and their answers, he couldn't refrain, of course, from occasionally using them, and hoisting his credulous friends by their own petards. The victims of his most celebrated hoax were Professor Hyslop of Columbia and Sir Oliver Lodge. Pure chance, in that case, had supplied him with the mysterious necessary knowledge. While crossing to England he'd been introduced on the boat to an attractive young widow who wanted his advice. Her husband had gone down on the *Titanic*. Subsequently she had met Professor Hyslop, who took her to a medium. She had an elaborately bound, typewritten report of all the sittings, and no human being save herself, the medium, and Hyslop had ever laid eyes on it. Now she wanted

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Wood to read it, and he did. Most of the messages were the usual clichés such as "waiting for you," "happy in this new life," etc., etc. But there was one phrase which had an element of novelty, on the page which recorded the dead husband's thoughts immediately before the boat went down:

"I am standing on the bridge near the captain . . . we are going down . . . the water is rising . . . it's up to my knees . . . to my waist . . . to my shoulders . . . this is the end. *The engines are coming up!*"

Now what could that have been intended to mean? Wood wondered. The widow too had puzzled over it. Perhaps a rush of steam as the water reached the furnaces? Not likely. It stuck in Wood's memory like a cocklebur, because it was peculiar. The lady was on her way to London, where she was to meet Professor Hyslop again. He was going to take her to a celebrated English medium from whom they hoped to get what the psychical researchers call "cross references." Wood, arriving in England, was the house guest for a few days of Sir Oliver and Lady Lodge.

After dinner on the second day (Wood tells me) Sir Oliver said, "Oh, by the way, we have another guest arriving tomorrow who is your countryman." "Who is it?" I asked. "Professor Hyslop of Columbia," replied Sir Oliver.

Hyslop arrived in due course, and after dinner I got them going on psychic phenomena. Presently I invented an imaginary instance in which a man's wife had drowned in her cabin when a yacht was sunk in a collision. Her husband had received "messages" from her describing her last thoughts as the water rushed in through the rent in the hull. Hyslop sat up and said, "That's *very* remarkable. I have a similar case *now*." "Tell it," we said. "Unfortunately I cannot, I've been sworn to secrecy. Nobody but the medium and a lady and I know the story." "Oh, but you can tell it impersonally, men-

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tioning no names, can't you?" I asked. "Yes, why not?" said Sir Oliver. "There's no breach of trust in that."

Well, he finally consented and spun a rather long story, to which I pretended to be listening dreamily. Finally he got to the point, "And then very remarkably he told us his last thoughts, 'I'm on the bridge, the water is rising, it's up to my neck, the—' The—let's see—what was it? Oh, yes, 'The machinery is rising!' Now what could he have meant by that? I've asked naval architects and sea captains, and they can't imagine."

I sat with bowed head, my eyes covered with one hand. *"No,"* I said, *"not* the machinery is rising—*the engines are coming up!"*

Hyslop jumped like a jack-in-the-box. "What made you say *that?"* he asked. "Say what?" I asked, waking up. He repeated it. "Did I say that?" I asked. "You certainly did, didn't he, Sir Oliver?" "Yes, he certainly did." "Well," I said, "if I said that I suppose it was because it came into my mind."

"The most extraordinary thing I've ever heard!" said Hyslop. "Telepathy with the subconscious mind! *That was* the communication, but I'd forgotten it."

I never confessed to either of them. Several years later, I again met the charming widow. She had ceased to be interested in mediums, and I told her the story.

Perhaps the most amusing comment on Sir Oliver was made by the Woods' maid, when Sir Oliver and Lady Lodge were house guests of the Woods in Baltimore. Sir Oliver was to deliver a series of lectures in The Lyric, which is Baltimore's "opera house." On the first night the hall was jammed. The public expected him to talk of spooks, ghosts, and the dear departed. His talk was pure science—abstruse and dry. On the next night his audience had dwindled to a tiny group of fellow-scientists. It seems, however, he'd talked earnestly enough of life beyond the grave at the Woods' table, for when

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he'd gone the colored maid, long familiar with Wood's Luciferian raillery, ventured to say:

"Miss Gertrude, it sure made a difference, having dat nice Evangelist in de house."

I asked Dr. Wood to venture a guess as to why such able scientific men as Flammarion, Crookes, Hyslop, Lodge, and others had been credulous and at times so easily duped—as they had been—by fraudulent spiritualists and mediums. He made a reply which I think throws a lot of light on it.

"The pure scientist," said he, "is trained to investigate nature's immutable laws, subtle and complex though they may be. He can perform controlled, quantitative investigations. When it comes to outwitting the guile of the human mind, where the laws are no longer immutable and the scene can be shifted to suit the circumstances, the scientist, despite his skepticism, who has *not* been indoctrinated in the art of tracking down the fraud, will in his ingenuousness be an easy dupe. The old adage, 'It takes a thief to catch a thief,' is only too well demonstrated."

I suspect that most of the scientific gentlemen, both among the public committees and the privately credulous, who have investigated or held traffic with the spiritualists and mediums, have been on the whole too soft and polite to apply in a literal and ruthless way Wood's quoted adage. This is partially understandable, particularly in the light of the fact that so many mediums are of the so-called tender sex.

I doubt, for instance, whether there is one among them save this ruthless devil himself, who would have dared to do what he did in the case of the Harvard-investigated Margery. . . .

The Harvard committee, after elaborate investigation, had pronounced the celebrated Boston medium fraudulent, but Dr. William McDougall of Oxford and Duke universities had hedged on it, and the Society for Psychical Research was wanting a further investigation. They induced Professors Knight

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Dunlap, H. C. McComas, and Wood to form a new committee of three and go up to Boston. Here is the account which Wood has given me of his own sardonic "meddlesomeness"—from the repercussion of which Margery was carried out screeching and fainting. It begins scientifically enough, but soon goes into clinches.

At one of the sittings (Wood says) I brought in an ultra-violet lamp of the type I developed during the war for secret signaling. It emitted a flood of invisible light, though to the eye it appeared only as a very dark red photographer's dark-room lantern. I asked permission to use this, representing that it was an especially dark light, which was true, and might be favorable to the manifestations. I had with me secretly a small camera with a lens of large aperture with which I felt sure photographs could be made. I showed the lamp to Dr. Crandon, Margery's husband, while the room was lighted, turned on the lamp, and asked him if it would be all right to use it. He said he would have to consult with the control, "Walter," a brother of Margery who'd died many years ago. "Walter" said it was O.K. As soon as Margery had gone into a trance, as signified by heavy breathing, the lights were turned down and the "phenomena" commenced. I turned on the ultra-violet light and got out my camera. But looking up I saw that all the bouquets of artificial flowers on the mantelpiece and various other objects in the room had been painted with phosphorescent paint and were glowing in vivid colors, in fact the whole place was lit up like a cathedral. I turned off the light immediately and made no further effort to use it, for the cat was out of the bag. After the sitting was over, Margery came up to me and said in a low voice, "Say, Professor, *what* kind of light was that you turned on there?"

I said, "Why? What's the matter with it?"

"Why, everything in the room, all the flowers and everything, was lit up," she replied.

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I said, "How did you know *that?* I thought you were in a trance." She laughed and walked away.

At another séance we were permitted to see the ectoplasm. I was sitting in front of a checkerboard which had been placed on the center of the table opposite Margery, the squares of which had been painted along the edges with luminous paint. Several objects were placed on this which were supposed to be moved by the ectoplasm. Margery had a luminous star attached to her forehead, so that we could keep track of her face in the dark. After a few minutes a narrow dark rod appeared, silhouetted over the luminous checkerboard. It moved from side to side and picked up one of the objects. Later on, as it passed in front of me, I reached out very carefully and touched it with the tip of my finger, following it back until I came to a point very near Margery's mouth. It seemed probable that she was holding it in her teeth. *A moment or two afterwards I took hold of the tip of it very quietly and pinched it.* It felt like a steel knitting needle covered with one or two layers of soft leather. Neither Margery nor the control gave any evidence of having realized what I had done—though we had been warned beforehand on no account to touch the ectoplasm, *as it would be sure to result in the illness or possible death of the medium.*

At the end of the sitting, Margery was alive and in good spirits. Beer and cheese were brought, and we talked over things that had happened. At these sittings everything was taken down by a stenographer and subsequently typed for the benefit of the committee. I said, "Oh, there's one thing I forgot to mention, and I should like to have it taken down now."

Dr. Crandon objected, insisting that only things said during the séance should be transcribed. I finally persuaded him, however, by representing it as a matter of slight importance, and he said, "All right, go ahead."

The stenographer got out her pencil, and I began dictating slowly and solemnly a complete description of my "experi-

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ment" with the ectoplasm. Margery gave a shriek and fell back in her chair, pretending to faint. She was carried out of the room, and the committee was asked to depart. Later they pretended she was dangerously ill for weeks as the result of my "brutality."

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CHAPTER EIGHTEEN

Wood and the Police—a Great, Scientific Detective Solves Bomb and Murder Mysteries in Real Life

A MORGAN case?" repeated Wood, puzzled and a bit impatiently. "You say a Morgan case? It must be a mistake. I never had anything to do with any Morgan case."

I said, "But, heck, it's here in this list of crimes, murders, mysteries, fires, bombs, explosions. . . ."

"Oh, of course," said Wood. "Why didn't you say explosions? It means the Wall Street bomb. I helped at the request of Tom Lamont, one of the Morgan partners."

The "Wall Street bomb case" was a wholesale murder outrage that will never be forgotten by New York. Just before noon on September 16, 1920, a driver who passed so completely unnoticed that no description of him was ever obtained left a horse-drawn yellow wagon at the curb in front of the United States Assay Office, across the street from the Morgan bank. He hitched the horse to an iron block and disappeared, forever, in the hurrying crowds. A few moments later, with the street even more crowded, the big barrel bomb in the wagon exploded, killing thirty-nine persons, crippling scores, inflicting slighter wounds on at least four hundred—also damaging the Morgan bank, the United States Subtreasury and Assay Office, and other adjacent financial buildings. Wood's account of his part in the case is as follows.

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Some days after the explosion, Lamont, who had a summer home not far from mine at East Hampton and whom we had known as a neighbor for years, phoned and asked if I would go in to New York the following Monday morning and see if I could find any clues which might lead to the reconstruction of the bomb and the possible apprehension of the perpetrator. This was my first invitation to participate in a criminal investigation, and I doubted that I could be of any help. But Lamont felt differently. He had seen my laboratory in the old barn, had heard me talk about complicated phenomena in physics and the chemistry of explosives. I went down, as requested, and was first introduced to Sherman Burns, son of Detective William J. Burns, then director of the Bureau of Investigation, Department of Justice, who had been called in to work with the police.

Sherman took me to police headquarters, where I was ushered into the private office of Captain James J. Gegan, head of the Bomb Squad. Standing in front of me, beside Gegan's desk, and leaning against the wall like a pair of old cavalry boots, were the two hind legs of the wretched horse which had drawn the cart containing a barrel filled with iron sash weights, with a high explosive bomb packed at its center. Gegan told me all they had found out, which amounted to very little beyond what everybody knew through the newspapers. The Morgan corner had been a shambles of dead and dying men and women. Nobody knew just what had happened. The troops had been called out, and everything was confusion. I asked Captain Gegan if they had subsequently found any fragments of the bomb's structure or mechanism, since these if identifiable might lead to conclusions concerning the occupation of the perpetrator—might even be traced.

Captain Gegan said, "No. We've gone over a cartload of stuff, swept up in the street after the explosion. There were the sash weights, of course, but we've gone over the debris

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with a fine-tooth comb, and there's nothing identifiable in the heap but parts of the wagon and harness."

I asked him if he still had the stuff, and he took me into an adjoining room where there was a pile that resembled the dirt and scrap heap behind a blacksmith shop. It didn't look promising, but I began grubbing. Presently I pounced on a fragment which I felt sure was a part of the bomb. It was a curved fragment of metal which might have been part of a thin-walled iron or steel cylinder, possibly eight inches in diameter. There was a hole in its center. On its outer surface and crossing the hole was a narrow lateral stripe, scored with deep parallel grooves or ridges. I had seen similar grooves on rock surfaces when studying geology at Harvard a quarter of a century earlier, which the professor called "slickensides," formed on the opposed surfaces of rocks subjected to great pressure and undergoing lateral displacement. I showed this to Gegan, and said, "Here's a part of the actual bomb."

After further search, I found not only half a dozen similar fragments, but some pieces of a heavy steel hoop. One of them had a hole the same size as that in the first cylinder fragment and curved to the same degree, so that the hoop must have fitted snugly around the cylinder. Moreover, these hoop fragments were "slickensided" on the *inside* where they had been pressed in close contact with the outer surface of the cylinder when it had exploded. They had been drawn under heavy pressure against it, and this, as in the case of the rock surfaces studied in geology, had formed the parallel grooves and ridges.

I said to Captain Gegan, "We can now reconstruct the container of the explosive. It was a steel cylinder, probably a long one, eight inches in diameter, bound with steel hoops, fastened to it with rivets or something similar, passing through these holes."

Furthermore, it seemed to me evident that it must have been originally a staple article or part of some staple article of machinery, extemporized as a container for the explosive. The

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next problem was to find out where it had come from, whether from a plumber's shop, an automobile factory, an engine factory, or where. This part, of course, was up to the police. I was overoptimistic perhaps about their skill in running such clues to earth. Captain Gegan asked if I had any further suggestions. I called his attention to the fact that all the iron sash weights had serial numbers and two letters cast in relief on their surfaces. I advised detailing a squad of police to scatter to every iron foundry within a radius of miles, with samples of the window weights, and to see whether any foundry could recognize them or identify their "vintage." Their age might show whether they came from a building that had been torn down or from a new one in process of construction. These might all be basic clues when suspects began to be rounded up and when their backgrounds, locales, and occupations were checked. I don't know what obstacles and dead ends the police ran into—but as you know, the perpetrator was never found. Since the police were aided by Burns and by the Department of Justice, and since rewards totaling over $80,000 were offered, it is a mystery they never got anywhere.

Dr. Wood recalls a little argument he had with Burns, Senior, concerning the window weights. Burns felt Wood was wrong in believing they could possibly have come from a new building under construction, or from an old building, either, for that matter. Burns insisted they had been on a junk pile, subjected to the weather for many years. In support of that theory, he pointed to yellowish ingrained discolorations on some of them. "But," Wood had insisted, "that's from the sandstone walls of the Morgan bank they hit."

Young Sherman Burns had said, "That's just what I told papa." Subsequent analysis of the discolorations showed that Dr. Wood and Sherman were right.

Some years later Captain Gegan, of the Bomb Squad, wrote a magazine article entitled "How I Reconstructed the Wall

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Street Bomb." Dr. Wood never objects, any more than does the fictionally famous "Dr. Thorndyke," when the police follow up suggestions he has given them and make good use of his ideas as their own. So, indeed, had Captain Gegan reconstructed it—after Wood had found the overlooked fragments and shown him how.

The Wall Street bomb was only a beginning. Wood was later called in to help solve, and did solve, the famous Brady Bomb Case, in Maryland—generally referred to in the annals of mysterious crimes as the Candy-Box Murder. In this case, Dr. Wood not only reconstructed the entire mechanism of the bomb, but turned advisory detective himself, and followed to their ends the clues which brought the murderer to justice.

Both the crime and its solution by Dr. Wood—if one merely pasted together the columns of space devoted to it by the Baltimore and Washington papers, without the inside story given me by Wood himself—had every dramatic element for a super detective novel, in which Dorothy Sayers and Austin Freeman (who invented Wood's best replica in fiction) might collaborate to put an end to all scientific detective novels—with Lord Peter Wimsey left out. Here's the true-life story reconstructed with the help of Dr. Wood, supplemented by reference to newspaper files.

Seat Pleasant is a sparsely populated, unimpressive rural hamlet, with modest houses, on the Carmody Road in Maryland, near the District of Columbia line. One of these houses was occupied toward the end of December, 1929, by a Mrs. Anna Buckley, with a family of small children, whose Christmas had been meager. On the evening of the day after Christmas, just before dark, she had chanced to go out on the front porch and remembered later that there was nothing on the porch and nothing near it on the ground. Her front yard was bare clay. Next morning when she went out on the porch

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again between seven and eight o'clock, there was a package wrapped in brown paper and tied with white string. It looked like a box of candy or cookies or something of the sort, left by a neighbor for her children as a belated Christmas gift. When she picked it up she was disappointed to find written on it, or rather hand printed, in bluish black ink, the name "Naomi Hall."

She didn't know anybody named Hall and was tempted to open the package, but being an estimably honest woman decided not to. The children, even more tempted, since they were sure it contained Christmas goodies, were told to "let it alone," since "it didn't belong to them." Mrs. Buckley didn't bother to lock the package away or hide it from them. They were obedient children—and somebody would almost certainly turn up to claim it before the holidays were over. There was in fact a family of Halls not far away on the same road, and they had an eighteen-year-old daughter named Naomi, but Mrs. Buckley didn't know of them. Apparently, either they or the Buckleys (the record on this point isn't clear) had moved there quite recently. . . .

Young Harold Buckley, seven years old, seems, however, to have known all the time who Naomi Hall was. Perhaps he didn't tell at home because he hoped she'd never claim the candy—and in that case—well, candy would still be candy, no matter how stale. However, on New Year's morning, when Harold was sent out on an errand and chanced to meet one of the Hall boys, Naomi's young brother Leslie, his honesty got the better of him, and he said, "There's a Christmas present, a box of candy or something, for your sister at our house. Somebody left it by mistake."

This burst of honesty on Harold's part saved his little life—saved the Buckley household from wreckage and horror.

Leslie got the package later and started home with it, accompanied by a boy named Steuart Carneal.

Naomi Hall was a generous, handsome, even if just then

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slightly overplump sister, and both boys hoped to share the candy. Naomi took the package to the kitchen table, and the kids, including Leslie, a younger sister Dorothy, and a toddling baby brother Samuel, gathered around her as she opened it. Mrs. Nora Hall, the mother, stood in the background. The Carneal boy was watching through a kitchen window, hoping to be invited in after the package had been opened. Naomi removed the string, took the paper off, and lifted the box's lid. There was an immediate and terrific explosion. Naomi was literally torn to pieces; Dorothy and baby Samuel were also killed outright. The table and kitchen floor were a mass of wreckage. The explosion had blown a crater in the earth beneath the floor; had also seriously wounded Leslie. Mrs. Hall lay bleeding and unconscious, with an eye and all her teeth destroyed. The Carneal boy, outside the window, had been wounded too.

The explosion brought the whole village, then the police from Washington, which was the nearest metropolis, and later that same day, the police from Baltimore, since the atrocity had occurred in Maryland. Also hearses and ambulances. When Mrs. Hall had regained consciousness, she said, "I was in the kitchen when Leslie brought the package in. We called Naomi to come in and open the box. We were all grouped around the table expecting to see a box of candy and nuts. Then I saw a white flash, and that is all I remember until I was being picked up on the back porch and put in the ambulance."

The bomb, while containing enough high explosive to wreck a house and massacre a family, had been directed to Naomi in person. But who would have wanted to murder Naomi? And particularly who could have wanted to murder her, yet had known her so slightly that he didn't even know where she lived! Naomi had been a simple, friendly, attractive country girl, knowing only simple country people like herself. Here indeed, from many angles, and particularly from that of the

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method which had been used, was an *unlikely* murder mystery.

Lieutenant Itzel and Detective Schalter of the Baltimore police department, who had active charge of the case, after they'd been called in to help the local constabulary, as Scotland Yard is called to rural districts in England, soon learned that Naomi Hall had been pregnant, and this circumstance, if not a clue, offered at least a first lead to work on. But here, almost immediately, the police came to a sort of double impasse. Naomi Hall had been for some time lawfully married to Herman Brady, a young farmer of the county. The marriage was on record, the young couple were on good terms, as far as anybody knew, and the marriage had been kept a secret from the two families only because Mrs. Brady, Herman's mother, had opposed it. It meant more mouths to feed. Herman was working his mother's farm. She was dependent on him, and he hadn't wanted to tell her about the marriage until he was in a better position to take care of them both. The first impasse confronting the police was the seeming lack of any urgent motivation for murder, even though a baby was expected in a few months. The second impasse was that Herman Brady, a hulking dirt farmer and not a very bright one at that, knew nothing whatever about machinery, mechanics, explosives—never tinkered with gadgets—had never done so in earlier boyhood—had no mechanical ingenuity whatever—couldn't even mend a broken plow—in short could no more have constructed an infernal machine than have built a rocket to the moon! Of this, the police were absolutely sure, and it turned out they were right.

Everybody agreed that Herman was too dumb to have done it.

"Now if it had been his brother . . . if it had been Leroy," said farmers, gossiping around the stove in the general store at Seat Pleasant. "And what about his brother?" the police were soon inquiring. Well, Leroy Brady was the opposite of

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Herman, they said. Just one of those differences that happen in so many families. Leroy was a sort of mechanical genius. But he was out of the picture. He worked, and lived, in Washington, had a good-looking young wife of his own, saw little of his mother and Herman—probably hadn't even known Naomi Hall at all. Leroy worked in a big Chevrolet garage—headquarters of the Chevrolet in Washington—and was one of the best mechanics they had. He was known to have displayed great ingenuity in devising mechanical contraptions, including a device for the opening and closing of doors.

The police weren't quite so sure, when they looked into it, that Leroy was "out of the picture." Yet they could discover no earthly connection or reason for Leroy Brady to have murdered Naomi Hall—except as a farfetched "favor" to his brother—and what had been learned up to then by examination and analysis of the bomb debris and fragments held nothing which pointed to their having come from *any* garage, much less any particular one. Steel fragments picked up in the bomb crater had been sent to the Bureau of Standards and the Bureau of Mines. The government experts' conclusions were that the firing mechanism had been roughly similar to that which creates the spark in an ordinary cigarette lighter, and that this had been attached by a tiny chain (passing through a tube) to the lid of the box. The explosive material, they believed, might have been acetylene. In moistening one of the fragments which had a white deposit on it, they had discerned an acetylene odor. (Acetylene was already long outmoded in 1930 for motor headlights, and pointed no longer particularly to a garage as it might have in the old first days of the Model T.)

The detectives had nothing whatever on Leroy Brady beyond the fact that he had the mechanical ingenuity to have devised the bomb—and was Herman's brother. So they were again at an impasse.

Dr. Wood, Johns Hopkins's great experimental physicist, was

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called in as a police consultant on the suggestion of Governor Ritchie. The suggestion was welcomed by District Attorney Parran and the police. Dr. Wood began to work directly with Lieutenant Itzel and his department.

They handed over to me immediately (says Dr. Wood) the small steel fragments which had been found in the crater under the floor of the Hall house, and which in the meantime had been returned to them by the Bureau of Standards. Then, very sensibly, they drove me down to the scene of the explosion, which I studied thoroughly. Everything pointed to dynamite. There was a hole about eighteen inches in diameter in the kitchen table and directly below it a hole through the floor nearly three feet in diameter. I came to the conclusion that the damage could be best accounted for by about half a stick of dynamite. Acetylene, I knew, could not have done it. Then, back at Johns Hopkins, in my laboratory, I began to examine the steel fragments.

There were four or five small pieces which had evidently formed part of a short length of steel tubing about ⅜ of an inch in diameter. They had been smashed flat by the explosion, but there was no question about their having formed a tube. The Bureau of Standards had sawed the original fragment into pieces and had pried one of them open after making a longitudinal cut with a saw. This opened section showed on the inside a number of spiral grooves, together with some small U-shaped pieces of steel wire. Close examination of these small bent fragments of wire, *which might have been chain,* convinced me of a totally different explanation and gave me my first clue to the real nature of the firing mechanism. I discovered, fitting them together end to end, that they must have originally come, not from a chain at all, but from a single continuous piece of steel wire, coiled inside the tube in the form of a spring. The force of the explosion had flattened the tube and broken the coiled spring into small fragments. I be-

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came completely certain of this when I discovered that the spring, pressed against the wall when the tube had been flattened by the explosion, had left a spiral groove around the inside of the tube. Though the spring had been smashed to pieces, it had left its "finger prints."

In addition, there were a number of short fragments of a steel cylinder, exactly the same diameter as the inside of the steel tubing, and on the end of one of these were the remains of a small disk of copper, firmly welded to it or "soldered to it for some purpose unknown," as the Bureau of Standards had reported. Prying it off I found a coating of a bright silvery metal on its back which *resembled* solder but which a magnet showed to be steel. It seemed probable that it was the remainder of a copper percussion cap that had been welded to the steel by the force of the explosion. The position of certain holes which had been drilled through the tube wall and also through one of the cylindrical fragments finally enabled me to reconstruct the firing mechanism which had exploded the dynamite, so I sent for the detectives and phoned the District Attorney's office. District Attorney Parran, from Upper Marlboro County, and Wilson Ryan, a Washington criminal lawyer, who had been assigned by Governor Ritchie to assist the District Attorney, together with Lieutenant Itzel, all arrived together.

"Well," they said, "have you found anything?"

"Yes," I replied, "this is it."

I took a piece of paper and drew a diagram of a short steel tube containing a spiral spring compressed by the cylinder carrying the percussion cap which was held back by a nail through the two holes in the tube and through the hole in the steel cylinder. At the other end of the tube was another short steel cylinder, also held in place by a nail. A string was tied to the nail, which held the cylinder carrying the percussion cap against the compressed spring; the other end of the string was attached to the lid of the candy box, so that when the box

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was opened, the nail was withdrawn, the released spring drove the cylinder with its percussion cap against the other cylinder, exploding the detonator that fired the dynamite.

They looked at the diagram in amazement. "Why," said the District Attorney, "that's *exactly* the mechanism of the rabbit gun."

"What's a rabbit gun?" I asked.

"A rabbit gun is a small brass twenty-two-caliber rifle attached to a log by a screw. The bait is carried on a wire attached to the trigger, the bait being in front of the muzzle, and when the rabbit takes the bait, the gun is fired and hits the rabbit in the head. But what makes your discovery exciting is this. We have evidence that Leroy Brady was taking one of these guns apart on his bench about two weeks before the murder."

"Did you ask him why he had been doing that?"

"Yes," they answered. "Leroy said he was taking it apart to remove the steel trigger and replace it with a brass one, because he was afraid the steel trigger would rust, out in the woods."

"That's nonsense," I said. "Any good mechanic would know that a brass trigger wouldn't work. The sharp, nicked edge which holds back the cocked hammer would wear away in no time with soft metal like brass."

I told the police that in my opinion, Leroy had taken the rifle apart to find out how the internal mechanism operated. I asked them to find and bring me the rifle if they could. I said it would probably have a brass trigger on it by now all right, since he wouldn't be fool enough not to put one on when he had a chance. In the meantime I realized that to make a case, we must find out if possible what the steel tubing had originally been made for and where it had come from. It had evidently been a gas-welded tube of commercial factory manufacture. Remembering, in this case, that the Wall Street bomb fragments had never been successfully traced, I decided

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to take on this search myself. I began by visiting personally a number of big hardware stores and showing them the fragments. They told me the tubing was not standard gauge and must be of foreign make. This did not satisfy me. I next wrote to the editor of *Iron Age,* the New York metallurgical journal, asking him to send me the addresses of all companies in the United States which manufactured gas-welded steel tubing. He gave me the addresses of seven or eight companies, and I mailed a fragment of the tubing to the first company listed, asking them to send it to the next on the list, and so on until it could be identified. It became a sort of chain letter. The first three companies to which it went could not identify it. But the fourth, the Republic Steel Corporation, replied, "We recognize this tubing as our manufacture. It is a bastard size and is made to order for General Motors to serve as the torque rod of the steering gear of the Chevrolet." The torque rod runs down the steering post, from the lever which advances and retards the throttle.

So the tubing in the bomb had definitely come from a Chevrolet garage or storeroom! Dr. Wood was making progress. But there were thousands of Chevrolet garages—hundreds in Maryland and the District of Columbia. It remained to be proven, if possible, that this particular tubing had come from the *one* garage where Leroy Brady worked. It seemed utterly impossible to do this. But our scientific detective in real life had made an additional microscopic discovery which might point the way.

Wood continues:

I had discovered a tiny, seemingly accidental imperfection, if you could call it that, in the tubing fragments—two parallel scratches, microscopically visible on all the fragments, along the tube's seam—made probably by a nick on the machine which had polished them. I went to Chevrolet headquarters

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in Baltimore, first of all, and asked permission to examine the torque rods they had in stock. None of them showed similar scratches along the seams. I then asked Lieutenant Itzel to send someone quietly down to the Chevrolet garage in Washington where Leroy Brady worked, to purchase and bring back a couple of torque rods from the stock there. These were brought to me, *and both of them had scratches identical with those on the bomb fragments, showing that they must have come from the same batch of material as the rod used in the construction of the bomb.*

The net was closing in. My findings now pointed more and more definitely to Leroy Brady.

I was certain, from the remains of the small copper disk welded by the explosion to the fragment of steel cylinder which had been part of the mechanism, that an old-fashioned percussion cap identical with those used for muzzle-loading shotguns had been used. Furthermore, another fragment of like steel cylinder Lieutenant Itzel had later found showed that a skilled workman had "turned" its end down to exactly the right diameter to fit such a cap.

I felt this might form an additional clue, since muzzle-loading shotguns were extremely rare as late as 1930, even in rural districts. I wasn't thinking any more about the twenty-two-caliber rabbit rifle which had merely supplied the model for the firing mechanism—but about where the shotgun cap had come from. The cap used in the bomb had been pure copper. I had Itzel buy several boxes of caps, each made by a different arms company, and analyzed the metal. All the types but one were made of brass, copper plated. Only the caps made by Remington were pure copper.

I was now ready to take a chance. I told Lieutenant Itzel to get a search warrant—to search the farm where Herman Brady lived, from attic to cellar, for a muzzle-loading shotgun, or for any evidence that there had been one there, and to

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look for a box of percussion caps. Three hours later he was back at my laboratory.

"Well, Doc," he said, "we found the muzzle-loader, and we also found a box of percussion caps on the mantelpiece . . . and they were Remington!"

I said, "Bring them in, and I think I can promise you the material for an indictment and conviction of one or both of the boys."

Lieutenant Itzel said, "Oh, we've got the shotgun all right, but we didn't bring the caps along. We left them on the mantel."

I sent the detectives back. But in the meantime the evidence had disappeared.

When District Attorney Ryan heard the story, he said:

"Well, I guess, just the same, we can ask the Grand Jury for an indictment."

"Not quite yet," I said. "I want to make a firing mechanism exactly like that of the bomb, with similar tube, springs, steel plugs, percussion cap and everything, and then explode a stick of dynamite against it and see whether we cannot get an exact reproduction of the fragments."

This was direct scientific experimental method, and the District Attorney had sense enough to approve it.

I asked Lieutenant Itzel to obtain the dynamite and arrange a place where we could go out into the country to try it.

In the meantime I had learned that a spring similar to the one used in the bomb was used in the manufacture of the door-handle mechanism of Chevrolet cars. From a piece of identical spring, therefore, from a piece of tube cut from that bought from the garage in Washington, and from a piece of steel cylinder obtained in our own Johns Hopkins machine shop, I made a model of the mechanism as I conceived it.

Next day I was driven in a police car out into the country, to the place of a man who sold dynamite. Behind the house was a shed in which he kept the dynamite and detonators. We

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cut off half a stick, attached my model of the firing mechanism to it, dug a hole in the ground, placed the combination at the bottom, covering it over with a large box, lighted a fuse, retreated to a distance, and let it explode. Digging in the earth at the bottom of the hole, we discovered the wreckage of the firing mechanism which I had made. In every way it was identical with the wreckage of the firing mechanism of the original bomb. Everything had been exactly reproduced, including the flattening of the tube, the spiral grooves on the inside, and the U-shaped hooks formed by the fractures of the coils of the spring.

The grand jury returned an indictment of both the brothers. The trial resulted in a hung jury, but at a second trial Leroy was convicted of second-degree murder and was given ten years. A good deal of the technical evidence had been ruled out, and he escaped the death penalty. Herman had been indicted as an accessory, but the case against him was dropped, despite the fact that he had accompanied Leroy when the bomb was delivered and the crime had obviously been committed to get him out of a jam. . . .

A year later, further confirming Leroy's guilt, a box was found, concealed in an abandoned flue of the garage in which he'd worked, containing eight sticks of dynamite wrapped in a newspaper dated just a little prior to the murder.

The old adage of the prophet without honor began to be disproven in Dr. Wood's case. Already famous in New York, London, Berlin, Vienna, for his work in pure science, he was now regarded by the police and populace of Maryland as a genius and wizard in the realm of bombs and high explosives (which interested him only incidentally). Soon, consequently, he was begged to aid in the solution of further crimes and mysteries.

From time to time throughout the intervening years, and

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still today, a stock three-column headline, with variations, announces in the Baltimore and other big southeastern dailies to all and sundry:

DR. WOOD SEEKS CLUE
TO NEW DEATH BOMB

or:

FAMED JOHNS HOPKINS SCIENTIST
CALLED IN TO AID POLICE

or simply:

WOOD INVESTIGATES THE CASE

Under the headline is generally, again with variations, the picture of a gentleman seated in a laboratory, surrounded by microscopes and more mysterious instruments, sometimes gazing at a pile of jagged metal, sometimes looking out the window. The profile is startlingly like that of Sherlock Holmes —and always includes the pipe. The pipe is no pose. He's given up cigars and never smoked cigarettes. Added to the keen Holmes, classic-actor profile, the pipe is just a piece of luck for the cameramen. These pictures appear also from time to time in New York and other metropolitan dailies when one of the investigations develops a national twist or angle, as was the case a few years ago, after which he was invited by J. Edgar Hoover to lecture before the G-man's police training school.

This followed another bomb murder, the assassination in 1932 of a well-to-do spinster. She was killed by a bomb attached to the muffler of the Buick car which she always drove herself. The retarded explosion occurred one day after she'd started the car, as usual, in her own garage, and had driven about two miles. It became vital, during the police investigation, to know definitely whether the explosive had, or had not, been dynamite. Their own experts were stumped, and

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Wood was again called in. With no usual clues to go on, he conceived the bright if startling idea of blowing up some more old Buicks.

"We located an 'auto cemetery,'" he says, "got a lot of dynamite and other explosives, and spent the afternoon blowing up all the old Buicks we could find, to the delight of crowds of little boys attracted from miles around by the noise."

Study and analysis of the debris proved with absolute certainty that the explosive in the bomb murder could *not* have been dynamite, but had been something entirely different—which was what they were after.

This "method," which nobody had ever thought of before, was outlined by Dr. Wood in his lecture at Edgar Hoover's school attended by police from all over the country. Soon the California police were using it successfully, and now it is a regular part of bomb-squad technique in dealing with similar cases.

Tragic and grimly fantastic was the mysterious death from an explosion in 1935 of Miss Emily Briscoe, daughter of a prominent Baltimore family—a case whose solution Dr. Wood later presented to the British Royal Society, of which he is a member, in a paper entitled "Optical and Physical Effects of High Explosives."

One winter Sunday afternoon in the Briscoe home, when the servants were off, the house became a little chilly, and Miss Briscoe went down to the furnace and opened its door to see if the fire was burning properly. The family heard a "bang" like a muffled pistol shot and then Miss Briscoe exclaiming, "Why, something stung me!"

When they rushed down, she was standing before the open door of the furnace, bewildered, clutching at her breast, and repeating:

"It was like a sharp sting. Something must have struck me —here."

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When they opened her dress, there was a tiny red mark, such as might have been made by the point of an ice pick. They were puzzled, were going to put iodine on it and phone the doctor. To their horror and amazement, the girl collapsed, and in less than three minutes was dead. There was no blood —just a tiny red puncture.

An autopsy by the city physician showed that a large artery had been cut, and that internal tissues had been torn to a considerable degree. Yet no projectile, no "bullet," no fragment of metal could be found. Finally an X-ray examination revealed a minute opaque object lower down in the body. Dissection disclosed a tiny, queer-shaped metal pellet, the size and shape of a grape seed, surrounded by a thin metal skirt. No one had ever seen anything like it before.

It was sent to the city chemist. On the insistence of the influential family of the dead girl, backed up by the demands of the newspapers, Dr. Wood was called into the case. He tells the story.

When I went down to the city laboratory, the chemist was surrounded by a group of reporters, to whom he was exhibiting the mysterious tiny fragment of metal, held in the palm of his hand. As I came in he said to the reporters, "I shall have no statement to make until I have analyzed this metal, and found out what it is. I shall then make my report to the coroner, after which it may be released to the newspapers. Until then I have nothing to say."

I knew the chemist very well, so I had no hesitation in being a little familiar with him. "It's obviously copper. There's nothing to be gained by analyzing it, which will destroy it and then we can't identify it. Let me have it, and I'll see if I can find out where it came from."

"What do you think it is?" asked the chemist.

"I think it is part of a detonator or dynamite cap which got into the furnace by mistake with the coal. It was probably

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lying on top of the coal, and when the furnace door was opened the flames came up through the unconsumed coal and ignited the detonator."

The reporters were all ears, of course, and I was captured and taken aside. "How can you find out about that?" they asked.

"Well," I suggested, "if you have a car here we will go out to a quarry and get some detonators and fire them."

The fragment of copper removed from the body did not resemble in the slightest degree any portion of the detonator. Here was a pear-shaped pellet of solid copper the size of a small grape seed, surrounded by a thin disk of the metal which hung down from the waist of the pear like a petticoat, while a detonator is a thin-walled tube of copper about the size of a twenty-two cartridge, and from an inch to two inches in length. At the lower end there is a dent in the copper which resembles the dent made in the cap of a shotgun shell after it has been struck by the firing pin. This dent plays a curious role and gives the detonator its deadly quality, as will be seen presently. It is filled with mercury fulminate, a very high explosive, and fired by an electric current through two wires.

We suspended a detonator above a block of hard oak about five inches square and fired it. A small hole was visible in the surface of the wood, and on splitting the block we found a small pellet of copper which had penetrated the oak to a depth of about four inches. The fragment was about the size of the one taken out of the body, but it had been considerably distorted by its passage through the hard wood. I accordingly secured a few more detonators and brought them back to my laboratory where I suspended one about two feet above a large earthenware jar holding about five gallons of water, pointing the head downwards. On firing the detonator the jar was shattered into a dozen or more pieces by the pressure wave exerted in the water by the passage of the small copper fragment (the head of the detonator) entering the water with three times

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the velocity of a rifle bullet, just as a milk can filled with water is burst open when the bullet of a high-powered rifle is fired through it. The minute fragment of copper which was found in the ruins of the jar matched perfectly the fragment found during the autopsy but bore no resemblance to the original head of the detonator.

As further examination of detonators showed that they contained nothing of the nature of this solid bullet, it was clear that it had been molded by the heat and pressure of the explosion from the paper-thin wall of the copper detonator tube. This discovery, for it really was a discovery, shows the importance of experiment in any investigation. Up to this time the formation of this solid pellet had never been noticed or described. Its formation resulted from the presence of the dent at the bottom of the copper tube, which the explosive experts had found increased the force of the dynamite exploded by the detonator without knowing why. The reason was now quite clear. The copper bullet traverses the entire length of the dynamite stick, with an initial velocity three times that of a rifle bullet. If there were only the thin fragments of sheet copper into which the rest of the detonator is blown the explosion would be started only at one end of the stick.

The problem of how this solid pellet was formed was solved by firing detonators loaded with different amounts of explosives into a long cylindrical pasteboard tube filled with cotton, diaphragmed with thin paper disks every two inches, the pellet being searched for in the cotton lying between the last disk perforated and the next intact disk. As the pellet, which starts off with an initial velocity of about 6,000 feet per second, penetrates the cotton it gathers a tightly wadded ball around it as it advances, spinning its own cocoon, so to speak, and is thus protected from friction against the matter through which it is passing.

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Until Dr. Wood made these discoveries, not even the technical experts on dynamite, blasting, and commercial explosives had ever known or dreamed of the terrific velocity this "pellet" expelled from the detonator possessed, much less the weird, sinister shape into which it became transformed.

These detonators, harmless-looking as an ordinary small cartridge, yet as deadly dangerous as rattlesnakes—often picked up by children around quarries—began to interest Dr. Wood. He learned that there are between three hundred and four hundred accidents from detonators per year in the United States, many of them fatal. He continued his experiments and issued warnings, which have already begun to cut down this category of accidents in which children are frequently injured, mutilated, blinded, and have in some cases lost their lives.

Said Dr. Wood: "Children fire them usually by putting them on a rock and striking them with a hammer or another stone. Parents and schoolteachers should warn children that if they ever find anything resembling a twenty-two-rifle cartridge with wires or a fuse protruding from it, they should give it a wide berth and should on no account attempt to explode it."

Wood's most far-reaching, though less sensational, contribution to the science of detection is known, curiously enough, throughout the world as the "Vienna Method," though it was invented in America, by an American, and given first to the American police. It is a device for detecting raised checks, superimposed forgeries, erasures and alterations in manuscripts, by photographing the material with ultraviolet light. Wood published the method about 1906; the alert Vienna police began to read about it, and wrote direct to Wood for further details, which he generously supplied, with additional suggestions. They then began publishing extensive reports in various important technical European police journals, giving Dr. Wood full credit for the invention but claiming its adoption by themselves. In consequence, even here in America,

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"Vienna Method" became the police-laboratory name for it.

Despite his major absorption in pure science at Johns Hopkins, Dr. Wood is still frequently called on by both the police and private parties to help solve this or that mystery—particularly if it has anything to do with fires or explosions.

Not long ago two lawyers, accompanied by a gentleman whose left hand was missing, knocked at the door of Wood's laboratory. It was explained that a serious accident had occurred on a turkey hunt. A shotgun had exploded at the breech, tearing off the hunter's left hand at the wrist so completely that it hung by a few shreds of muscle and skin. The gun was one of the most expensive on the market, guaranteed by one of the most prominent firms dealing in firearms, and the victim was about to bring suit against the company for heavy damages. A chemist who had analyzed a fragment from the barrel was ready to testify that it was made of a low grade of steel and showed evidence of flaws, but the lawyers wanted someone who had specialized in explosions to serve also as expert. They had brought the gun with them, a twelve-gauge shotgun of aristocratic family.

Wood examined it carefully. The explosion had occurred in the barrel at a distance of about three inches from the breech, and at first sight he could not understand how such a serious break at this point could have been caused by a normal cartridge.

After examining the inner surface of what remained of the barrel with a magnifying glass, he laid the gun down and said: "Gentlemen, you've assigned me to the wrong side of the case. The explosion was due to the circumstance that somebody had slipped a sixteen-gauge shell into the twelve-gauge gun by mistake. It had slid into the barrel and stuck where the barrel narrowed above the breech. Subsequently a twelve-gauge cartridge had been introduced and fired. The simultaneous explosion of the two cartridges exploded the barrel." Wood pointed out that bright, brass-yellow stains could be

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seen at several spots on the inner surface of the barrel, and taking a penknife he succeeded in detaching two small fragments of thin sheet brass, which had been welded to the steel by the force of the explosion. These fragments had exactly the thickness of the sheet brass from which the head of a sixteen-gauge cartridge is made.

There was an uproar. The owner of the gun insisted it was impossible. He had no sixteen-gauge shells in his pocket, did not even own a sixteen-gauge gun. He had fired the gun a few minutes before the accident, had inserted another twelve-gauge immediately, and closed the breech.

Wood said, "I can't help that. A sixteen-gauge got in somehow. Someone in the gun club may have picked up a shell that had been dropped on the floor and put it in the pocket of your hunting coat that may have been hanging in the vicinity. You slipped it into the gun after firing, and then a few minutes later, not being sure whether you had reloaded or not, opened the breech, and seeing that it was empty (the sixteen-gauge having slipped down out of sight) you inserted the twelve-gauge."

The owner was aggressively positive about the impossibility of such a fantastic theory. He remembered exactly what he had done, and after a long argument the group departed. Wood noticed that the two small fragments of brass were still on his desk, and he put them carefully in a pillbox and tucked them away in his desk drawer, in case they should be required subsequently.

The lawyers, however, still wanted his testimony in regard to certain other facts connected with the explosion, and pointed out that only such questions would be put to him as could be answered without reference to the yellow metallic stains and fragments of brass. But Wood declined to go on with it. "The other side may employ an expert who will notice the stains, and their counsel will ask me in cross-examination if I didn't observe them, and I will either have to commit per-

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jury and say 'No' or give a truthful answer, and then be faced with the question: 'Did you point this out to the prosecution?' "

They decided to go ahead with the case without Wood, and the trial was slated for a certain date in New York. Some weeks later it was dropped.

Another queer case in which he confounded the conventional experts occurred in Baltimore in 1938. With a set of childish miniature tenpins, he knocked the stuffings out of a lawsuit which had been brought against the Pennsylvania Railroad by some twenty householders who claimed that the rumbling vibration caused by passing freight trains was demolishing their walls, ceilings, and plaster.

Their houses lay along a street in South Baltimore down which a railroad track ran on which several trains passed daily. Heavy trucks also passed along the street, but the suit was brought against the railroad. The claims were so fantastic that the railroad knew they couldn't be true, yet was in a quandary how to disprove them before a jury. A saloon keeper was going to testify that the bottles fell off his shelves when freight trains went by; another family would testify that windowpanes were shattered and plaster knocked off the walls; and one man actually testified at the trial that his wife had been thrown out of bed one night when a train passed.

The railroad at great expense had brought seismographs and seismograph experts, including one man whose specialty was making records of vibrations caused by quarry blastings. The seismograph recordings proved, of course, that the lawsuit was phony, but were so technical that the railroad realized they wouldn't be much use for the jury. So, just as the police and federal government had done in many similar criminal cases, the railroad called in Dr. Wood.

Wood scratched his head, said, "Give me a couple of days," and turned up the second day with a set of tiny wooden tenpins, all of the same size but standing on bases of different

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diameters, decreasing from ¼ inch to that of the most sensitive tenpin, which stood on a base only 1/32 of an inch in diameter.

The railroad executives looked at the toys and said, "Are you kidding us?"

Wood set up his toys on a table and said, "Now tap on the table."

Nothing happened. He said, "Tap a little harder." The tenpin with the tiniest base promptly fell over.

Wood said, "Now hit the table as hard as you can with your fist."

The three next smallest tenpins fell over.

Said Wood, "If you kick the table a little or hit it with a hammer they'll all fall over." One of the big executives said, "My God, I believe you've got it!"

So with the tenpins in their pockets and a long strip of plate glass to serve as a foundation, Wood went down to the district, accompanied by the claim agent and the lawyers. They went from door to door, but no householder would let them in. They'd been warned by their own lawyers.

They finally found an honest old lady who was persuaded to let them in. She even let them go up to the third story where vibration would be at its maximum. Says Wood, with a grin:

I set the plate glass on the window sill, leveling it with a spirit level, and balanced the row of tenpins. Presently a heavy beer truck rolled by, on our side of the street, and the pin with the tiniest base swayed to and fro a bit, threatened to fall, but regained its balance. Presently the big afternoon freight train came puffing and rolling along. The tiniest pin didn't even tremble. Presently one of the old lady's grandsons came tearing up the stairs to look at the toys. When he burst into the room to see what was going on, the tenpin with the smallest base upset.

Here was something any jury could not only understand but

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enjoy, and when the case came to trial and the tenpins were set up in court, not only was it thrown out, but some of the jurors burst out laughing and had to be reprimanded by the smiling judge.

Last summer when he chanced to take me into the littered storeroom of his big laboratory at Johns Hopkins I spied a scarlet-purple feminine dressing gown or wrapper, draped dramatically over a recumbent telescope. I thought he'd put it there as a joke, and asked him whether he kept a harem. Its presence and history, however, were anything but funny. A Baltimore lady wearing an identical wrapper had been burned to death when the wrapper had been ignited, perhaps by a carelessly tossed match. The material went under a trade name and seemed to be a kind of chenille. Fire spreads over it almost in a flash. A lawsuit was pending in which Wood had been asked to investigate the danger of such textiles.

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CHAPTER NINETEEN

Wood Turns a White Girl Black— Continues His Mighty Labors— Travels and Collects His Medals

ALL THROUGH the thirties Wood continued his experimental work. But he was internationally famous now, and in demand everywhere to attend learned societies and receive rewards and medals. All through the decade he was leaping from America to Europe and back again, and always finding time for a strenuous social life and his terrible poltergeist pranks.

He was asked to write the article on fluorescence for the fourteenth edition of the *Encyclopaedia Britannica.* He wanted to reproduce a picture of the human face taken by the light of the ultraviolet lamp he'd invented during the war. By these invisible rays, the whitest skin appears dark chocolate, the teeth shine with a ghostly blue light, and the pupil of the eye appears white instead of dark. As he was crossing one of the university corridors he said to a pretty typist, to whom he had never said anything before except a vague good morning:

"How would you like to have your picture in the next edition of the *Encyclopaedia Britannica?"*

"What on earth, Dr. Wood? You're kidding me, of course!"

"Not at all. I mean it. Would you like to?"

"Why, yes! But how, and why?"

"Come along," he said, "and let me take your photograph. It's to illustrate the article I'm writing, and I want a pretty girl for it."

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He took her to his laboratory, set up the camera, lighted the ultraviolet lamp, drew the black window shades down, and made the exposure. A year later as he passed the office, he said, "Look up the article on 'Fluorescence' in the library upstairs, and you'll find your picture." She did, and screeched, for her blonde face was black as any cornfield Negro's. It's the nearest thing to a mean joke Wood has ever played on a human being.

In 1929, he went back to London with Mrs. Wood and Elizabeth. On the boat were Dr. Mayo of the Mayo Clinic, Dr. Yandell Henderson, Yale physiologist, and Sam Barlow, the composer . . . so the Woods had congenial company. The stay in London was as usual a combination of busman's holiday for Wood, and fun for all of them.

John Balderston had a play in rehearsal at the Lyric in which the time was supposed to change from the present to 1783, during a moment while the stage was in darkness. How to make the switchback emotionally and psychologically effective was a problem which Wood offered to solve. His idea was that the lowest of all notes, subaudible but vibrating the eardrum, would produce an eerie sensation, and put the audience in a mood for what followed. It was accomplished with a super organ pipe, larger and longer than any used in church organs, and was tried out at the dress rehearsal. Only Wood, Leslie Howard, Balderston, and the producer, Gilbert Miller, in the small audience knew what was coming. A scream from the blackened stage indicated a time relapse of 145 years. The Wood subaudible note was turned on. An effect occurred like that which precedes an earthquake. The glass in every chandelier in the old Lyric commenced to tinkle, all the windows rattled. The whole building vibrated, and a wave of fear spread out to Shaftsbury Avenue. Miller ordered the so-and-so organ pipe thrown out immediately.

This, by the way, was only one of Wood's ventures in the theater. Flo Ziegfeld, a neighbor of the Woods in East Hamp-

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ton, was a frequent visitor to the barn laboratory, and after seeing the miracles effected by invisible light and other special rays, asked if Wood could devise a system of lights and costumes of special material which would disappear when the stage illumination changed, leaving the girls practically naked. Wood worked it out completely. To make it funny, the comedian was to appear with a chorus of girls in evening dress. He was to carry an "X-ray" field glass, and to explain that their clothes vanish when he looks at them. As he turned the glass on them, the lights would change, and they would appear stark naked to the audience. He was then to turn the X-ray field glass on the audience.

It was a little too soon for so daring a strip without the tease, and the act never went into production. Wood gave Ziegfeld other ideas, however, having mainly to do with stage lighting, which were incorporated in the Follies, year after year.

In 1934 Wood was elected vice-president of the American Physical Society and attended the annual meeting of the Pacific Coast Section in Berkeley, California. The sessions were held in the buildings of the University of California, in conjunction with the meeting of the American Association for the Advancement of Science. The attendance was large, and each member was required to wear a large button with his name on it.

George Kaufman's political satire, *Of Thee I Sing,* exploiting "Wintergreen and Throttlebottom," candidates for President and Vice-President, had been the hit of the season in New York. As Wood was now vice-president of the Society, he wrote "Throttlebottom" on his badge, and the meeting at once divided into two groups, a minority which was onto the gag, and a majority which was not. The badge was continually supplying amusing situations, as when an elderly lady at a garden party introduced him by his stage name to a circle of her friends, and when a young professor who had just in-

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troduced him to two charming young ladies as "Professor Wood," was corrected by them, glanced at the badge, made profuse apologies, and added, "A most extraordinary resemblance."

After the meetings at Berkeley were over, Wood hurried back East, picked up Gertrude, and together they sailed for Europe and the International Congress on Radio-Biology at Venice.

The opening meeting of the congress was held in the Doge's palace, in the Grand Ducal room. Especially invited foreign delegates sat in a semicircle on the enormous dais. Marconi, president of the congress, gave the first address.

Wood had been asked to show the motion pictures of the Tuxedo experiments with supersonic waves. His lecture was delivered in English, and because of anticipated interest, arrangements had been made to have it translated sentence by sentence, as delivered, into three additional languages. It began something like this: "Ladies and gentlemen, I take great pleasure in being able to show you with a motion-picture machine the results . . ."

At this point the polyglot interpreter raised her hand and said, "One moment, please . . . *Messieurs et Mesdames—c'est avec un vif plaisir que je me trouve capable de vous montrer, à l'aide du cinéma . . . Meine Herren und Damen, es ist mir eine grosse Vergnügen dass ich im Stande bin Ihnen zu zeigen, mittels einer Maschine für Lebendebilde . . . Signori e Signorini, sono molto lieto di potervi dimostrare oggi i risultati delle nostre esperienze per mezzo cinematografico. . . .*"

She paused and looked encouragingly at Wood. By that time he had completely lost the thread of even the simple phrases with which he had begun his talk. One can imagine the predicament in which he found himself when a similar treatment was applied to the technical part of the description. Wood remarked, "Why my highly sophisticated audience did not drown this polyglot nightmare in waves of laughter, I have

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never understood." He says this was the most painful experience he has ever had on a lecture platform, especially as he had heard his wife remark to an Italian, who had been bored by the long papers that had been given, some of them lasting over half an hour, "Well, you won't be bored by Mr. Wood's lecture, because he always gives his addresses in the shortest possible time."

Marconi's famous yacht, the *Electra,* was anchored in the harbor. This was the yacht on which all of his experimental apparatus was installed. But none of the members of the congress was invited on board. The only exception, Wood says, was Arthur Compton's little boy, who was interested in wireless.

The Woods were given a cocktail party at one of the cafés on the Piazza San Marco. The Marconis were invited to the same party, but told their hosts they could come only after dark, since their appearance in public in daylight caused a crowd to collect, and the crowd usually followed them about from place to place. They appeared about dusk and sure enough, within a minute or two, people began converging on the cocktail party from the entire Piazza, whereupon the Marconis arose hastily, excused themselves, and disappeared.

In April, 1931, Friedrich W. von Prittwitz, the German Ambassador at Washington, on behalf of Berlin University, and at a large reception given in honor of Dr. and Mrs. Wood at the Embassy, presented Wood with an honorary Ph.D. By that time the fact that the famous Johns Hopkins professor was not a Ph.D. had become a sort of academic joke. Most incipient professors, while still young, take the pains to obtain the degree before they so much as dare apply for an instructorship in any first-class college. Wood doesn't blame Harvard for overlooking him. It wasn't Harvard's fault. He just hadn't bothered to do the routine. And in the meantime he'd been given, from his own and a dozen other countries, nearly every

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degree, gold medal, silver medal, bronze medal, and academic honor [1] that could be showered on a scientist.

Now that Berlin belatedly had capped his LL.D.'s with a fine new *Herr Doktor's* Ph.D., "made in Germany," our hero was duly grateful, but didn't take it oversolemnly. At the lecture and subsequent banquet given in his honor when the Woods visited Berlin that summer, he couldn't resist trotting out the magic, humanity-dividing powder he'd been playing tricks with in America and in England, where he and Mrs. Wood had stopped the week before.

I quote from Wood's notes concerning what happened when they reached Germany.

I gave an illustrated lecture on some results I'd obtained with some new types of spectra I'd discovered, and the serious part of the visit was over. At the end of the banquet, which was an evening affair attended by professors and wives, an amusing speech was made by von Laue, discoverer of the method of photographing crystal structure by means of X rays. He said a Ph.D. (*honoris causa*) from Berlin University was a rare honor, requiring the unanimous vote of the entire faculty, and that so far as he knew no physicist had received it before. As some members had never heard of the proposed recipient a copy of his book on *How to Tell the Birds from the Flowers* had been passed around at the meeting, and this had made the vote unanimous.

I made a halting reply in bad German, in which I tried to

[1] In addition to his medals and awards, Wood has the degree of LL.D. from Clark University, University of Birmingham, England, and Edinburgh University; Ph.D., University of Berlin; is foreign member Royal Society, London; honorary member London Optical Society; corresponding member Königliche Akademie der Wissenschaften zu Göttingen; foreign member Accademia dei Lincei, Rome; Russian Academy of Science, Leningrad; member American National Academy of Science, Academy of Arts and Sciences, Philosophical Society, Physical Society; honorary member Royal Institution, London; honorary fellow London Physical Society; foreign member Royal Swedish Academy, Stockholm; foreign member Indian Association for Science, Calcutta.

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tell the story of a Japanese professor who "wished very much to buy very many copies of very funny book to send to very many friends in Japan," and was able to sit down under cover of laughter. Gertrude didn't think I'd made a sufficiently grateful acknowledgment, and made a pretty speech of her own, expressing our gratitude and the pleasure we'd experienced in renewing old friendships—all in better German than I had been able to grind out.

During my short talk I happened to mention that I'd brought over a sample of a newly discovered chemical (a derivative of sulpho-urea) that was absolutely without taste to about 40 per cent of humanity, while to the remainder it was as bitter as quinine, and that any who cared to sample it could be accommodated. Later on, when I produced the little pill-box filled with the flourlike white powder, I was surrounded by a crowd of German *Herr Professors* and their *Fraus,* holding moistened, outstretched fingers, and all crying:

"Bitte, bitte" (Please, please).

Then came a terrific general argument and uproar.

"No, it tastes not at all!"

"But yes! *You* have no taste!"

"It is *terribly* bitter!"

They almost came to blows over it.

In 1935 Wood was elected president of the American Physical Society, and was obliged to attend again the Pacific Coast annual meeting, which was in Pasadena. He chose high explosives as the subject of his presidential address and enlivened it with stories of cases he'd solved for the police.

As he was descending an elevator after the annual dinner, one of the members came up to him and said,

"Dr. Wood, will you forgive me if I ask a rather impertinent question? You seem in a good mood, and I'd like to risk it."

"Shoot," said Wood.

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"Are you a Christian Scientist?"

"No," Wood replied. "What put that in your head?"

All he could answer was that he'd heard it somewhere.

It was only later, when Wood told his wife about it, that she remembered Margaret's attempt, as a little girl, to uphold the family honor. She had confided to her mother one day that the neighbor's little girl had said, "We are Episcopalians. What are you?"

"And what did you say?" Gertrude asked.

"I said we were Christian Scientists," Margaret answered. "You see, I knew papa was a *scientist,* and I supposed we were Christians."

In the summer of 1936, the Woods went to Mexico, which seemed to them, except for Egypt, the most interesting country they had visited. Wood's enthusiasm for archaeology came once more to the fore. He was particularly interested in the obsidian razors, made by the Aztecs in Montezuma's time, and he asked several local archaeologists how they were made, but no one seemed to know. Obsidian is a black volcanic glass, and the razors were thin narrow blades, very sharp along both edges, not over 1/16 of an inch thick and five or six inches long. He worried over this problem, until one day, in poking about over a pile of excavated material at the great pyramid of Cholula, which is so vast that it carries on its summit a large modern church, he picked up an obsidian five-sided "peg." He recalled one of his old laboratory experiments, and this gave him a clue. The razor might have been made at one fell swoop by a blow of a hammer against one edge of the pentagonal top of the "peg"; in other words it was a long, keen-edged "chip." Examining the five edges at the top, he found that each one had a roughened spot, where the hammer blow had fallen. He had frequently made "paper-thin" mirrors in the laboratory which had one edge "razor sharp," by silvering a piece of plate glass, standing it on edge, and hit-

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ting the upper edge a sharp lick with a hammer. The thin chips that scaled off were often half an inch square and very light. These he used as reflectors in photometers, or for galvanometer mirrors. He didn't experiment with his obsidian specimen, as he felt sure that his twentieth-century skill as a manipulator would not come up to that of a half-savage Indian in the pre-Cortez age.

In 1938 Wood took a transcontinental motor trip, from Chicago to Berkeley, California, with Professor and Mrs. F. A. Jenkins and their two boys. He went to Pasadena, and to the Mount Wilson Observatory, where two of his eight-inch diffraction gratings had been installed in the spectrograph of the great 100-inch telescope in place of the glass prisms formerly used. Dr. Dunham had already made some new discoveries with them, the most exciting being that interstellar space is filled with the vapor of ionized titanium, the vapor being of such extreme tenuity, however, that it manifests itself as a black absorption line only in the spectra of the most distant stars, the line being much narrower and blacker than the lines belonging to the star itself.

On the way home he spent a week at Flagstaff, Arizona, visiting Dr. Slipher, the present director of the Lowell Observatory, where they made preliminary experiments with a new type of grating for photographing star spectra without a slit. Back in East Hampton, Gertrude joined Wood in a trip to London and Cambridge, where the British Association was holding its annual meeting. Wood gave a communication on a new combination of two prisms and two diffraction gratings for measuring star velocities, which was favorably commented on by Professor Harlow Shapley, Director of the Harvard Observatory, who was in the audience. He also showed motion pictures of the animated crystals of protocatechuic acid, which he had been studying for the past two years. The man assigned to operate the machine lent for the occasion had plenty of trouble. It would start, stop, run backwards for a second or

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two, then forwards continuously instead of intermittently, giving an imitation of a shower of rain on the screen. This went on and on, the operator becoming more confused each minute, and two hundred people were waiting patiently in the dark. Finally Wood called out, "Is there a doctor in the house?" And a young man in the back row dashed down the aisle and had the machine running perfectly in ten seconds.

Following the Cambridge meeting the Woods spent a week in Oxford for the meeting of the Faraday Society, then to London during "Crisis week," with everyone rushing for gas masks and all of the parks swarming with men digging trenches. Wood refused to accept gas masks, as they were sailing for home the following week, and he didn't think the Germans would start things with gas anyway.

It was this same year in London, 1938, that Wood was finally awarded the great gold Rumford medal by the Royal Society. If I understand correctly, this medal is like the coin in the wedding cake. That is to say, it seems to be the best within the best. To begin with, foreign membership in the Royal Society is the highest scientific honor Great Britain can award a non-Britisher, and after they've had that piece of cake, rare members are rarely awarded the Rumford medal too. It's apparently even more complicated, however, for there's also an American Rumford medal, which Wood received in 1909. Wood has the cake and the coin too. He is a foreign member of the Royal Society and recipient of the medal. Here was the Wood gambit:

1909: Dr. Wood was awarded the American Rumford medal by the Academy of Arts and Sciences, Boston.

1914: Dr. Wood was recommended for the British Society's gold Rumford medal by Sir Joseph Larmor, but nothing came of it.

1919: Dr. Wood was elected a foreign member of the Royal Society.

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1924: Dr. Wood was recommended again for the Royal Society's Rumford medal by Merton, and nothing came of it.

1938: Dr. Wood finally got the gold Rumford medal.

The Royal Society and the Rumford medal require a bit of further explaining to the American lay audience. Both go back for centuries. The Society was incorporated in 1662, and is the oldest in the world, with the exception of the Accademia dei Lincei in Rome. Sir Isaac Newton was elected a fellow in 1672, and wrote to the secretary, "I shall endeavour to show my gratitude by communicating what my poor and solitary endeavours can effect. . . ." A succession of great names occurs in the Society's annals through the centuries, and around 1790 or 1800 that of Count Rumford blossoms. He was a celebrated colonial British-American scientist, and he founded the award in double, to be given in America by the American Academy of Arts and Sciences, and in England by the Royal Society. A curious final tangling fact is that Count Rumford himself was the first recipient of his own medal in England!

Wood is no help at all in explaining why it was now given to him. On subjects of this sort he becomes impatient. He has stuck all his medals in an old dresser drawer behind his wife's shopping lists.[2] Some of them, including the gold ones, are about the size, to exaggerate a little, of the toasted buttercakes

[2] Among the notable medals for outstanding scientific achievement of which Dr. Wood is the recipient are the following: 1899: medal awarded by the Royal Society of Arts for his diffraction process in color photography; 1907: the Franklin Institute John Scott medal, awarded by the City of Philadelphia for further progress in diffraction color photos; 1909: gold and silver Rumford medals awarded by the American Academy of Arts and Sciences for research on the optical properties of metallic vapors; 1910: the J. Traill Taylor medal, awarded for photography by invisible rays; 1918: gold medal, awarded by the Società Italiana della Scienze, for general outstanding scientific achievement; 1933: the Frederick Ives medal, awarded by the Optical Society of America for distinguished work in physical optics; 1938: the gold and silver Rumford medals, awarded by the Royal Society, London, for his daring and genius in experimentation; 1940: the Draper gold medal, awarded by the National Academy of Science, Washington, for contributions to astrophysics and spectroscopy.

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you get in Childs. The only thing I ever found worth quoting from his notes concerning the Rumford medals was this:[8]

"You get, in each instance, a silver replica of the gold one, presumably in case you wish to cash in on your winnings in your impoverished old age. The Royal Society gold one weighs 15½ ounces."

Sir William Bragg's speech in presenting the medal to Wood is the best summary of his achievement, and I quote from it:

Professor Robert Williams Wood is awarded the Rumford medal. The study of physical optics owes much to Professor Wood, who has been one of the leading experimenters in this field for the past forty years. There is hardly a branch of the subject which he has not enriched by the touch of his genius.

Before the advent of Bohr's quantum theory, when our knowledge of the structure of atoms and molecules was very meagre, he had discovered the line and continuous absorption of sodium vapor, the phenomenon of resonance radiation of gases and vapors, and the quenching of this radiation by foreign gases. These discoveries opened up rich fields of research and were of the greatest value to later workers in laying the foundations of the theory of atomic and molecular spectra.

The elucidation of the phenomenon of resonance radiation demanded the utmost experimental skill and resource. Nothing less powerful than an improvised 40 ft. focus spectrograph sufficed for his work on the remarkable resonance spectra of molecules! Even now one cannot but admire the beautiful and ingenious experiments on the independent excitation of the yellow sodium lines.

In addition to his researches on the resonance radiation of metallic and other vapours, Wood investigated their magnetic rotation and dispersion. His work on the magneto-optics of sodium vapor both in the atomic and the molecular state is now classical.

[8] I managed to dig up, however, an article entitled "Americans and the Royal Society from 1783 to 1937," written by Heathcote Heindel and published in *Science*, March 25, 1938, which threw more light on the general subject. Only six American physicists have ever been elected to foreign membership in the Society: 1889: Henry A. Rowland of Johns Hopkins; 1895: Samuel P. Langley of the Smithsonian Institution; 1897: J. Willard Gibbs of Yale; 1902: Albert Abraham Michelson of Chicago; 1919: Robert Williams Wood of Johns Hopkins; 1935: Irving Langmuir of the General Electric Co.

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More recent but belonging to the same domain of experiment are the very interesting discoveries of Wood and Ellett on the magneto-optics of resonance radiation.

Wood's mastery of technique is universally acknowledged. He has introduced many ingenious and striking devices to experimental method. These are too numerous to catalogue here, but I would mention specially his method of the production of atomic hydrogen and his observations of the spontaneous incandescence of substances in atomic hydrogen which led to the invention of the atomic hydrogen welding torch by Langmuir; his very efficient and now widely used method of observing Raman Spectra; his echelette grating which has proved to be the grating par excellence for the investigation of the near and far infra-red; and his pioneer use of light filters in ultra-violet and infra-red photography.

If you ask Wood himself why he got the medal, he is quite likely to tell you it was because he introduced smoking in the hitherto forbidden precincts of the Royal Society's sacred halls! One day, long ago, tea and cakes were being served in the majestic anteroom, when Wood became absorbed in talk with Sir William Crookes and lit his pipe. A flunkey in knee breeches and braided coat appeared as if by magic and whispered, with a mixture of awe and horror:

"Very sorry, sir, but smoking is not allowed."

Wood says he was so engrossed with Crookes that he went on smoking. Crookes stared, hastily produced a cigarette, and lighted it. In another minute, others lighted up—and the Royal Society has smoked there ever since.

If this episode were unique in Wood's biography, it might have slight significance, but many similar smoking anecdotes are told of him, and where there's smoke there's always fire. One of the strongest *leit motifs* through this man's whole life has been his curious, not always conscious affinity with flame. It illumines his Promethean-scientific side and is always spilling over in his pranks, both Huck Finnish and Mephistophelian. In the light of the fact that he led the revolt against Madame Curie's objection to smoking at the Solway Conference in Brussels, had a somewhat similar adventure at the

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Royal Auto Club in London, etc., etc., one has the right to suspect that when he lights his pipe where he shouldn't, the bad little boy who loves to play with fire and shock his Aunt Sally is still hiding behind the absent-minded great man and grinning.

When asked to lecture before the Philadelphia Forum, he chose "Flame" as his subject, and turned the dignified stage of the Academy into a cross between a Blitzkrieg and Vesuvius. There were sheets of blaze, acetylene torches, showering white-hot globules of molten steel—huge tubes of blue fire that whistled and shrieked before they exploded. Leopold Stokowski sat in a stage box. He had often conducted on the same stage—but this beat the burning of Moscow in the *1812 Overture*. . . .

When the curtain went down, Wood wiped his brow, pulled out his pipe, and was striking a match, when the fireman backstage called, "Hey, you can't do that!"

When this Promethean prankster, whom I then scarcely knew, took me for the first time to his big laboratory at Johns Hopkins, he turned his back for a couple of minutes, near a basin, then blandly offered me a *handful of fire*. It burned like an alcohol flame, but it was not much hotter than a cucumber.[4] I've a notion that if I hadn't accepted it, I mightn't be writing his biography.

I began trying just now to explain the serious connection between Dr. Robert Williams Wood, the Royal Society, and the gold Rumford medal. If I've slid into writing about Wood in Flames, it's doubtless bad structure—but it's all part of the same picture.

In the summer of 1939 Wood had turned seventy, and you might imagine that he'd sit down and rest for a couple of minutes, or even lie down and take a nap. Instead, the Woods were off for the West Coast again for experiments with the

[4] Cotton waste wet with a mixture of two parts of carbon tetrachloride and one part of carbon bisulphide.

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new type of diffraction gratings at the Lowell Observatory at Flagstaff and at the Mount Wilson Observatory at Pasadena.

Arriving in Pasadena, Gertrude went to Hollywood, where her sister was living, and Wood went to the Observatory for experimental trials of some new gratings he'd made. One placed over a three-inch Schmidt camera of five inches focus gave a fully exposed spectrum of Arcturus in five seconds. With an exposure of ten minutes he secured a sharp photograph of the spectrum of the Ring Nebula in Lyra, which was "going some" for a camera of only five inches focus. These experiments set a record for short exposure stellar spectra with a slitless spectrograph. The photographic plate was only half an inch square, but the definition of the spectrum lines was so perfect that on an enlargement of nearly thirty diameters, the lines were less than one-third of a millimeter in width.

This was preliminary to the real spectroscopic feat he'd embarked on, which was to make a diffraction grating large enough to cover the great eighteen-inch Schmidt camera, with a focus of thirty-six inches, the instrument with which Dr. F. Zwicky was discovering super novae at a rate that caused astronomers to gasp.

In the summer of 1941, Wood was throwing boomerangs at his biographer in East Hampton, and casually starting again for California, with gratings for the eighteen-inch camera.

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CHAPTER TWENTY

Wood as a Boomerang Thrower—as Amanuensis to a Thunderbolt—and as an Amateur Infant Psychologist

This triple tale of a curiosity-inflamed Promethean poltergeist begins with lightning and boomerangs, circles properly back to the point of departure as boomerangs should—and then sails off, still boomerang-propelled, into amateur experiments in infant psychology, including a gunpowder plot directed at his own innocent and bored baby granddaughter. Yet the man has kept complaining that I make him out a monster in parts of this narrative. . . .

When I went out, on Mrs. Wood's gracious invitation, to their summer place at East Hampton last June for a few days' quiet rest from work on this biography, I found myself chasing all day long in the fields surrounding the farmstead, at the heels of this unextinguishable Crile Elk who never gets tired of anything, at an age when most learned professors are occasionally fain to sit down or take naps. Our main expeditions were across the road into a big field spotted with daisies, where he threw the boomerang and tried to teach me to do it. Previously he had led me to a clover field beyond the barn laboratory, where he had taken his celebrated "autograph of a thunderbolt."

The thunderbolt's "signature," which still hangs in the barn, and which was reproduced with photographs and an article

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some years ago in the *Scientific American,* was obtained by Dr. Wood just after it had nearly killed him. Said he, showing me the spot:

"A heavy storm had passed, and the sky was blue overhead. I started across this small field which separated our house from that of my sister-in-law. I had gone about a dozen yards along the path in the grass when my daughter Margaret called to me. I stopped for perhaps ten seconds, and just as I started off again a brilliant blue line of fire came down from the sky with a report like that of a twelve-inch gun, striking the path about twenty feet in front of me and sending up an enormous white cloud of steam. I walked on to see what record the flash had left. There was a withered patch of clover about six inches across, with a hole in the center half an inch in diameter. If Margaret hadn't called and stopped me, I'd have been 'on the spot.' I went back to the laboratory, melted about eight pounds of solder, and poured it into the hole."

What he had dug out after it hardened looks like a slightly bent, oversized dog whip, cast in metal, heavy as dog whips are at the handle, and tapering gradually to a point. It is slightly over three feet long. My own surprise was that it hadn't penetrated the earth more deeply.

When we'd returned to the house for tea, I noticed a boomerang reposing on the mantel in the living room. It was a large one—no toy. It was what I suppose a bushman would call a business boomerang. It was made of hardwood, polished, smooth.

"Did it come from Borneo?" I asked.

"I made it myself," replied Wood. "I've made a lot of them."

He took me across into the big daisy field, and for the first time I was watching an expert throw the boomerang. The stance, form, and follow-through seemed more complicated than those in golf, tennis, discus-throwing, or anything I knew. The stance of the discus-thrower in Roman sculpture is closest to the stance Wood took—right foot well forward, shoulders

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bent to the left, the boomerang held far to the left and backward, with the arm curved behind the waist. Then forward on the left foot, with the boomerang coming up, vertical, high above the right shoulder. As the final step or leap forward is made with the right foot, the boomerang is thrown overhand and perpendicularly—and a little downward, almost as if toward the ground. Instead of striking the ground, it turns over on its side, when properly thrown, and then begins to soar upward in a sweeping curve. When well thrown, it completes the curve and returns to the thrower's feet. The sport is not without danger. Experts have been in hospitals with broken kneecaps and other injuries.

Dr. Wood encouraged me to try. I managed after repeated trials to make the boomerang rise once. But not in a good flight. Boomerang-throwing requires as much form, practice, and skill as top-notch tennis or golf.

That evening I said to Wood: "You are supposed never to have shown much interest in games or sports. How did you happen to take up boomerangs?"

He said: "It touches aerodynamics, of course, and I suppose my first interest was technical . . . scientific. But it soon occurred to me that the best way to learn about them would be to throw them myself."

He loves to talk, and this is what he told me.

While I was a student at the University of Berlin, back in 1896, I chanced to be thumbing a bound volume of the *Annalen der Physik*, published some twenty years previously. By accident I ran across an article on the flight of the boomerang. It was largely a mathematical treatment by some long-dead *Herr Doktor* who had probably never thrown a boomerang in his life—and maybe had never seen a real one. It was filled with aerodynamical equations that I didn't understand. But there were diagrams of the different paths of flight the boomerang could take, circles, figure eights, etc., that fascinated me.

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There was a footnote stating that "boomerangs were obtainable" at a certain toyshop in Berlin, at a cost of one mark fifty each. I hunted up the address and found that after all those years the shop was still operating. But the young salesman had never heard of boomerangs. I insisted, and finally an old patriarch was summoned who shook his head solemnly, scratched it, and then said slowly, *"Ja, ja, warten Sie einen Augenblick. Na—ich erinnere mich"* (Yes, yes, wait a minute. Now I remember).

Calling for a stepladder, he climbed to a shelf about ten feet from the floor, tossed a lot of stuff aside, dug out a large parcel wrapped in brown paper, which shed clouds of dust as it came down, and disclosed half a dozen small wooden boomerangs, toys really, of rather light weight. I bought them all, such as they were, hurried home, and repaired immediately to a large open lot behind our apartment in Charlottenburg.

After false starts with all sorts of wrong holds and deliveries, I finally began to make them come back a little, and eventually learned to throw them. I brought some of the boomerangs back to America, and one of the duties imposed on me as instructor of physics at the University of Wisconsin was to give every autumn a boomerang demonstration to the undergraduate class in physics which numbered some three hundred. It was their favorite "lecture" of the year, and always attracted large crowds of gapers from other departments and from the town.

A few years later while on a lecturing visit to England, I became acquainted with Professor Walker, the mathematical physicist at Cambridge, and it turned out to my joy that he too was a boomerang enthusiast. From him I learned to make and throw real boomerangs, made of ash, quite heavy, and with which orbits of much greater diameter could be obtained. These were real weapons, similar to those used in Borneo and the Malay Peninsula. Careful shaping of the surfaces was necessary, giving to the implement, in a slight degree, the proper-

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ties of a screw propeller. In this way the rapid rotational energy was utilized in supporting the implement when in horizontal flight. I was introduced also to the "war boomerang," a still heavier implement with the arms bent only at a small angle. This was not intended to return, but flew along a few feet above the ground for a much greater distance than it was possible to throw a war club or spear. It is my guess that the "returning boomerang" is perhaps used by primitives only for hunting aquatic birds in flight. If thrown through a thick flock, flying above the water close to shore, it would return to the shore if it missed. It would need to be retrieved, together with the bird, only when a hit was made.

Any heavy boomerang in flight (continued Wood), especially the "returning" ones, can be dangerous. Some time after I'd known him in England, Professor Walker was giving an exhibition with his boomerangs, in Washington, D. C., before a group of scientists. Distracted for a moment by the crowd of bystanders while one of his returning weapons was in flight, he was struck just below the kneecap and was in the hospital for several weeks. My Berlin boomerangs had been toys. In America I ordered from a bent-furniture factory a dozen boomerang "blanks," made under my instructions by bending an ash plank three inches thick through a right angle and sawing it lengthwise into sections. These I shaped with a drawknife at East Hampton, and gradually learned to duplicate the performances of my British colleague.

Dr. Wood stopped talking, as if he'd given me that whole story, but according to some things I'd heard in Baltimore, he hadn't told me the half of it. His hobby had started a small boomerang cult in Baltimore and added to the interest in Washington, where one or two statesmen had already attained high skill in throwing them. President Theodore Roosevelt, summer neighbor of the Woods out on Long Island, wrote, "I wish I could trespass on your kindness by getting you to bring

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over that collection of boomerangs. . . ." I learned in addition that Wood had been "false modest" in that phrase about "learning to duplicate." According to Baltimoreans, he had learned to do things with a boomerang that neither Professor Walker from Cambridge University nor the wildest man from Borneo would have cared to risk. As, for instance, here's one I'd heard, and taxed him with. The Johns Hopkins football team, as I'd heard it, never seriously pretended it could beat teams from universities of its own rank, but kept on having games in Baltimore, though attendance had dropped, since the home team nearly always got licked. So the athletic department thought up the bright idea of inviting Professor Wood to give a boomerang exhibition as an additional attraction with the next game. Wood accepted with a childish and innocent smile. There was a huge attendance, air conditions were perfect for miraculous stunts with the boomerang, and the exhibition was superb. The crowd applauded and was filled with joy . . . until (as I'd been told by Henry Mencken) our wild man of Baltimore stalked straight toward the low, uncovered grandstand, took his finest stance, and let fly a big boomerang (Mencken said war boomerang) point-blank at his audience. It rose and soared, as he had planned. He was so diabolically sure and expert that he intended it barely to skim over the heads of the topmost row and return to his feet. But an excited man in the top row stood up, with an umbrella. The boomerang took the umbrella as the wild man of Borneo takes the waterfowl, while women shrieked and students applauded, imagining that the whole thing, umbrella, stooge, and all, had been part of a cooked-up, William Tell apple act, by their favorite master of sensationalism both inside and outside the laboratory.

Dr. Wood heard me with pained indignation. He denied that it was a *war* boomerang—it couldn't have been—and said it was absurd to imply that anybody had been in danger or terrorized. "You seem to take a sadistic delight," he said, "in

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any apocryphal version of my conduct that makes me out a monster."

"But you don't deny, do you," I asked, "that you threw *a* boomerang into the grandstand and that it hit an umbrella?"

"No, of course not," he answered impatiently, "but . . ."

We were still barking at each other when we went in to dinner, and as Mrs. Wood was carving the roast he suddenly said, "How old were you when you began to remember?"

"Maybe between two and a half and three," I said. "What of it? Isn't that about the time most psychologists agree . . ."

"No, you're wrong," he said. "If they agree, they're wrong. I'm convinced it can and does sometimes go further back. I've done some experimenting with it, and . . ."

We were interrupted by the not always long-suffering lady who had been engaged up to then in more polite conversation with the second generation at the other end of the table.

"Now please, Rob," said she, "don't repeat that old story about fuzzy-wuzzy. If you must tell him about it, tell him some other time. The family's all heard it a thousand times."

"But, my dear," said he, in a mild, mock-henpecked voice, "I wasn't going to tell him that at all. We were talking about boomerangs."

He subsided into the imitation of a hurt silence, and I said to Mrs. Wood, "Please, what on earth was fuzzy-wuzzy?"

"We got sick of it," she said, "and so did the baby. When our granddaughter Elizabeth was about a year and a half old, he began exploding gunpowder, cannon powder, in the hearth of the living room, with the baby in his lap, saying fuzzy-wuzzy to the baby. . . ."

"It didn't *explode,*" said Dr. Wood. "Nobody ever tells anything right but me. It merely went off with a beautiful bright flame. But I wasn't going to tell you about that. I was going to tell you about the experiments I tried on our daughter Margaret when she was a baby—with the boomerang."

"Pray do," I said. "I beg you to tell me about both. John

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Watson experimented on his babies with brass gongs, snakes, and rabbits, but I've never heard of anybody using gunpowder and boomerangs."

"It was when I first began throwing them in Berlin," he said, "when Margaret was about two years old. It occurred to me that the boomerang in flight might be an ideal phenomenon with which to test a theory I had conceived concerning earliest childhood memories. My theory was that the authentically 'remembered events' were those which had been kept alive by subsequent associative words, remarks, or events which tied in with the original event without reconstructing, describing, or duplicating it. It was important to select the 'event to be remembered' in such a way that the baby could be reminded of it in words that would not in any way reveal the event's core or essence—otherwise the doubt would always arise that all she really remembered was being told about it later. Moreover, it must be an event not likely to be duplicated later, as there'd be no way of proving that the child really remembered any further back than the later duplication.

"For these reasons, the phenomenon of the boomerang in flight, whose essence was its return to the thrower, seemed ideal for the experiment. I took Margaret out to the back lot for a whole afternoon and threw my boomerangs. She watched their flight, saw them circling back to my feet, and toddled to help me retrieve the few which occasionally failed to return. I kept her near, and on several occasions it was necessary to snatch her from the path of the returning weapon. I never showed them to her again, but for the next month or more I kept asking her every day or two, 'Do you remember papa's throwing something?'

"For a while, if she said anything in reply, it was merely 'yes,' which proved nothing. But on one memorable day she added, *'Come back.'*

"Then for a year or more, until she was perhaps three, I re-

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peated the question at longer and longer intervals. As a mature woman now, she clearly remembers the actual boomerang flights that day in Berlin, and of seeing the thing circle around in the air, as her first actual childhood memory of anything . . . though her mother is still in the habit of saying, 'No, you only remember your father's telling about it.' "

"I still don't believe it," said Mrs. Wood cheerfully, "and I don't suppose there's any use now in trying to stop you from telling what you did to Elizabeth."

Dr. Wood beamed, taking this for an invitation, and said to me, "You saw the enormous fireplace in the living-room there, with the old Dutch oven at the back. Well, when my granddaughter was about a year and a half, I stood a small bronze dog in front of this black cave and placed on its head a button of German cannon powder, of which I'd brought home a bagful from the war. It looks like a heavy button, you know, a thick black disk with a hole in the middle. With the baby in my lap I touched a match to it. It flared up with a vicious, bright-yellow flame, which burned for about five seconds.

" 'That's the fuzzy-wuzzy,' I said to the baby.

"I repeated this experiment every day for a week, always saying 'fuzzy-wuzzy' when the powder burned. Then I said 'fuzzy-wuzzy' or 'Do you remember fuzzy-wuzzy?' to the baby every day for a month or so until her mother took her away. I hopefully expected that her mother would say 'fuzzy-wuzzy' to her in the intervals of their absence. The reactions of baby Elizabeth, however, were different from those of Margaret who had always politely lisped 'yes' to my question. At every family reunion, the baby was as bored as these uncooperative adults of my family, and whenever I said, 'Do you remember fuzzy-wuzzy?' she always answered, 'No!' Sometimes she laughed slyly. So we hadn't the remotest idea whether she remembered anything or not.

"The revelation came when she was nearly five years old.

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I hadn't uttered the hated words for a long time when one day at lunch she looked at me and whispered, 'Fuzzy-wuzzy.'

"I said, 'What?'

"This time she repeated, louder, 'Fuzzy-wuzzy!'

"I turned to her mother and said, 'What's she talking about?'

"Her mother said, 'I don't know.'

"The little witch hesitated for a moment and then said in disgusted triumph, *'You do know too! You put the dog in the fireplace and put fire on its head.'"*

Little Elizabeth was evidently a chip off the old block, and wasn't taking grandpa's experiments lying down. The one they tell of her which I like best concerns the memory experiment with the hayride. While she was a tiny tot, she and a playmate named Nancy were taken for a ride on top of a load of hay. Then Dr. Wood began with his "do-you-remember's." She refused to be the guinea pig. She never answered anything but "no" or nothing, and it was he who gave up. When the haymaking began across the road on the following year, her mother asked her point-blank one day, "Do you remember riding on the haycart last summer?"

She glanced reproachfully at her grandfather, gave her mother a look of betrayed and outraged indignation, and replied,

"No! *And I don't remember Nancy either!*"

I agree with Mrs. Wood and the relatively conservative members of the family that it's difficult to prove anything with the boomerang story, since Margaret herself can be mistaken—can have later overheard or seen something which described or duplicated the original event. But I think the hayride story proves a lot of amusing things that didactic child psychologists are prone to ignore or soft-pedal.

As for Dr. Wood's basic theory, which he continues to defend—well, maybe you've got something, Professor, even though you've stepped out of your own field into Watson's.

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Dr. Wood believes he's found a vindication of his theory that memory of events can be "fixed" by associative events even in the case of infants too young to be reminded of them in words. In his recent autobiographical *As I Remember Him,* the late Hans Zinsser wrote:

The minds of little children are like rolls of cinema film on which long series of unco-ordinated impressions gathered by the senses are caught. Usually most of these fade in later years. It is only here and there, in the earlier years, that an experience impresses itself with sufficient coloring to remain as a memory for life. My earliest reminiscence goes back to when I must have been between one and two years old. It was like a vaguely remembered dream, until I found later in speaking of it that it was based on fact. I remembered *clouds in a blue sky* against which the spars of a ship were swinging to and fro, and at the same time I heard a little tune sung with German words. Later I learned that I was taken abroad as a baby and that my father often sat on the deck of the old *Moselle* and sang me to sleep in his lap with the little song. As a boy I would often—especially before going to sleep at night—hear him singing again, see the swinging spars against clouds scudding across the blue sky.[1]

Dr. Wood believes the memory of the sky and moving spars had been repeatedly called up by the frequent repetition of the song through later years, and that it was this accidental associative prodding of the auditory memory that had fixed the visual impression. He proposes an experiment in associative memory fixation which he hopes some enterprising parents interested in child psychology will try out on babies too young to know the use of words. It involves the three senses of sight, smell, and hearing. He would like to have it tried on babies not more than one year old, and believes that "earliest memory" could probably be pushed back to an astonishing degree. As is well known, odors and tunes are powerful stimulants in suddenly recalling events or situations long passed.

[1] *As I Remember Him: The Biography of R. S.,* by Hans Zinsser. Boston: Little, Brown and Company.

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A spectacular arrangement of colored lights on a wheel revolving against a black background or in a dark room, or some such device, would be suddenly exposed to the view of the baby, and at the same time a simple but distinctive tune would be ground out on a toy music box, while the air would simultaneously be perfumed by a spray from an atomizer, preferably an odor unlikely to be encountered again.

Then at frequent intervals the baby would be subjected to the combination of two "reminders," the tune of the music box and the spray of the atomizer, which would recall and fix, as Wood believes, the more entertaining event of the gorgeous revolving wheel of bright colors.

"A much simpler way of trying the same thing," he added, "would be to sing a little tune and let the baby smell a perfumed handkerchief, while the wheel turned."

I said, "Why don't you try it yourself—with the revolving wheel? You love tinkering and gadgets."

He promptly replied, "Get me the babies, and I will."

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CHAPTER TWENTY-ONE

Wood in the Bosom of His Family—or How the Woods Take Care of Their Prodigy

In the early twenties, John Rathbone Oliver inscribed on the guest book at East Hampton a tribute in verse to the Wood tribe. It—the verse, not the tribe—is graciously Victorian, abounding in polite conceits.

I would I were Professor Wood
With wisdom in his bean.
He's F.R.S.—and other things—
I don't know what they mean.

I would I were like Mrs. Wood
With music in my heart,
And to the discords of my life
Could harmony impart.

I would I were like Margaret
(The spouse of Victor White)
Who paints and sketches all day long
And dances all the night.

I would I were her baby boy,
In blue and knitted hose
Who gurgles in his milk bottél
And wrinkles up his nose.

I would I were like Robert Wood
With keen, unerring eye,

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Who drives at golf two hundred yards
And smites the baseball high.

But there's another friendly Wood
I have not mentioned yet.
The Woodiest of all the Woods,—
The name's Elizabet.

I would not wish to be like her
Because, of course, you see,
The thing I really want's to have
Elizabeth like *me.*

Except for the Victorian restraint and for the passage of the years during which Margaret's children have grown up, Elizabeth has married and become mother of another little "Elizabeth," etc., it remains a fair picture of the tribe. All the gracious comments are still true today. The Woods are indeed a gracious family—but that's not the whole picture by a long shot. The Woods are also a fantastic family. This is not surprising, since the old New England stock from which they stem has brightened American history with many fantastic characters and families.

In truth the whole clan, when gathered together for family reunions or summer holidays, takes on some of the qualities of Sanger's Circus, or of an imaginary play by Bernard Shaw and Noel Coward in collaboration. Robert, Jr., by the way, though extremely fond of beautiful young ladies, has remained a bachelor, is a business man in New York, and is generally to be found at the Harvard Club on his off evenings. A while back, he wrote a funny book entitled *Hold 'em, Girls!* It's a Harvard man's post-Emily-Post etiquette for young women invited to football games. The youngest imp in the household when it reunites is six-year-old Elizabeth Bogert, who has inherited more than her share of her grandfather's prankishness and curiosity. When I first visited Dr. and Mrs. Wood in Baltimore, and while they were telling me about the second and third generation, none of whom I had yet met, Mrs. Wood

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said casually, "Elizabeth married a Dutchman." I'd expected he'd be at least as Dutch as Hendrik Willem van Loon, but when I later met Ned Bogert, I discovered him to be Dutch—like the Kips and the Roosevelts. His people had been in New York ever since New Amsterdam was founded. The Woods are pure English stock—and pure New England stock—on both sides, since colonial times. They are fond of their son-in-law and treat him as a son, but "Elizabeth married a Dutchman."

They are all full of violent opinions and prejudices, happily never the same ones, and if any opinion apart from family loyalty *were* ever shared by any two of them at the same time, the astonishment would be general. They engage frequently in debates which at times terrify the guest or stranger. Later he becomes even more bewildered. Robert, Jr., will denounce his father with the freedom and eloquence of an ex-artillery officer, or vice versa, and next morning they'll be as affectionate as if they were "buddies" of the same generation. It's the same with all the family. One night last summer at East Hampton, Mrs. Wood got into a hair-raising dispute with her son-in-law over the respective merits of certain Flemish and Italian paintings, and at the height of their difference exclaimed with outraged finality, "Well, that's just what could be expected from a Dutchman!" Ned Bogert and I were tying some luggage on the back of a car next morning, when a heavy thundershower came up. I had on a leather coat, but Bogert had no raincoat or covering and was dressed for the city. Mrs. Wood rushed out, dragged him into the house, made him take off his wet jacket, felt his shirt to see whether he should take that off too, hung his jacket to dry before the morning log fire, and found him a raincoat. I stopped gratuitously worrying about the Woods' family "quarrels." The subjects on which they engage in Shavian denunciations and dialectics are seldom personal and never boring.

There is always, for instance, the tender subject of Dr. Wood

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and the piano. The legend is that after the age of sixty he learned to play the piano and executed the noisy Rachmaninoff *Prelude in C sharp minor* with such pyrotechnic brilliancy that all and sundry were astounded—and appalled.

"The story," he said, "is grossly exaggerated—and all wrong anyway. I never played for guests, in Baltimore or here or anywhere."

"What about your daughter's version?" I asked.

"It's utter and absolute nonsense, and the thing isn't worth so much talk anyway. I don't see what you want to put it in the biography for at all."

I said, "What *she* told me is worth putting in anybody's biography. If her version is apocryphal, suppose *you* give me the true version." (Incidentally, he can't whistle or hum "Yankee Doodle" to save his life without getting off the key.) He said:

Well, to begin with, I was given music lessons for a year or two when I was about twelve years old—and I hated 'em. The teacher was a maiden lady who came to the house. You know the sort. Mendelssohn's Songs without Words, and sugared tunes *ad nauseam*. Anyhow, I was taught to read music, in a way, but rarely spent any time at the piano until the end of my second college year. At Kennebunkport where we went in summer, there was a young Miss Banfield in the hotel, who was a wow at the piano. She played the Schumann *Grand Sonata* brilliantly and frequently (by request). I was captivated, and said to myself, "I'm going to play *that*." I had a piano in my room at college, mainly for the benefit of visitors, and on my return invested in the score of the sonata. I was taken aback by the price, as I'd never bought a "composition" before. Above the opening bar was printed *"So rasch wie möglich"* (As fast as possible) and on the third page, *"Noch schneller"* (Still faster). This was stimulating and quite different from songs without words. I went after it hammer

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and tongs, and after a year or two could play the whole of the first movement without notes. By the time our second child was born, I was through the second movement. Then my musical, long-suffering, devoted wife had a respite during our two years in Berlin where I could not get at a piano. But I played it through Chicago, Madison, and Baltimore until my children were old enough to join forces with their mother and persuade me to desist—from the Schumann sonata.

What I did in revenge was to buy the score of Rachmaninoff's *Prelude,* with a red-seal record for a music teacher. This went even faster than the sonata, i.e., "faster than *faster than possible.*" It suited me exactly, but I was finally silenced for good and all by home influences.

Dr. Wood's version, as above, is circumstantial and beguiling, but it doesn't alter the fact that his daughter Elizabeth, Mrs. Bogert, "the Woodiest of all the Woods," painted me a different picture of her papa's ultimate atrocities on the pianoforte. Even if Dr. Wood is telling the partial truth and Elizabeth is embroidering the facts a little, it presents a pretty clear picture of how she *felt* about it. She says he came home one day in Baltimore with the *Prelude* under his arm, and began banging it out on the family piano. It was terrible for the family, she says, but in a month or so it rolled out with the inhuman perfection of a speeded-up electrical player piano. She says he became so inhumanly mechanically expert that it was really perfect—but that it was also "perfectly awful," and that for a period thereafter he drove the family frantic by adopting the following tactics toward occasional guests or innocent strangers. When one would say, "Professor, do *you* play the piano?" he would smirk deprecatingly and reply, "Well, only a little. I can only play one or two tunes." He would go to the piano, while the innocent victims would anticipate nothing worse than "Chopsticks" or "In the Shade of the Old Apple Tree." Then, while the family stopped its ears

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with mutual glances of commiseration, out would come crashing the whole *Grand Sonata,* or the *Prelude,* to its bitter end, while the chandeliers and ceilings trembled.

I tried to persuade Gertrude Wood to give me the exact and *definitive* version of all this, but she said, "There are limits to human endurance. I long ago refused to hear any more of *it,* and I now refuse to hear anything more *about* it." He refused to play for me, so the legend must remain a legend—despite the fact that its central figure is alive, and will doubtless remain so for many a long year. The Woods are tough as the towering oaks of their New England.

Dr. Wood can drive a car—and can carve—as well as anybody when he keeps his mind on it, but doesn't like to do either. Mrs. Wood consequently does all the carving and most of the driving. She likes to keep the indicator between fifty and sixty when roads are suitable, and on occasion steps it up to seventy and over. None of the Woods is slow or static. Dr. Wood's preferred and almost only alcoholic beverage is the Old-fashioned, or in lieu of that a dry Martini. Mrs. Wood makes them very dry. He frequently has one or two before dinner. I was writing these notes in East Hampton, after one of the dinners, and had written, "Mrs. Wood does all the carving, and, to paradox an old Scotch phrase, despite her husband's terrific personality, Wherever she sits is the head of the table." I asked her kindly to look the script over, and left it on her desk. When I found it next morning, she had turned author herself and had written across the top of the page, "The *Professor* sits at the head of the table. Gertrude carves so that he can talk to his guests—or if not, so he can think out problems which are often solved during the meal—at which times he is sometimes silent when he should be talking."

There's another Scotch phrase, by Bobbie Burns, which ends, ". . . to see ourselves as others see us." I still insist that Gertrude Wood sits at the head of the table, and not merely be-

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cause she does the carving. For she directs the conversation, no matter how brilliantly her husband dominates it. Sometimes she makes him talk, when he has been silent too long, and she has also been known to explode with the well-bred Boston equivalent of "For God's sake, shut up!" when his conversational pyrotechnics risk setting fire to some inflammable guest.

The household is hospitable, enjoys parties, people, gaiety. The rambling, remodeled Queen Anne farmstead, with ample space and appurtenances, has made it convenient in summer to entertain week-end guests, and they have had many famous ones. The guest book, with its autographs, verses, and frequent drawings, reads like a recipe for goulash concocted from *Who's Who* and the *Social Register* with a dash of gossip sauce from the *New Yorker*.

The galaxy of autographs, touching both the starry firmament and Broadway's neon lights, ranges from great astronomers to Dwight Fiske. They've even entertained Harpo Marx, by accident, and a celebrated safe-cracker by design. Nearly every autograph has some tale or reminiscence connected with it. One of the richest concerns the late Charles Nungesser, French ace of aces, who flew out to East Hampton during his last visit to New York, and left the following inscription: *"A Monsieur Wood, et sa famille, en souvenir de leur charmante réception à mon arrivé en avion au golf."*

The "charming reception" accorded him when he landed on the golf course might well be written into next year's script of *Hellz-a-Poppin*.

Robert Wood, Jr., and Nungesser had met one evening at the Harvard Club. The two young veterans had a lot to say to each other over the Scotch and sodas, and when Nungesser learned that the Wood summer home was at East Hampton, he mentioned the fact that he was flying out to the Maidstone Club for lunch on Saturday. So-and-so, or a *Monsieur Tel* as they say in French—he didn't quite recall the name, *mais un garçon charmant*—had invited him. He had written the name

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down, but couldn't just then recall it. He hoped Robert and his father would join them there for lunch or coffee or a drink.

Late Saturday morning, seeing a tiny plane high over the farm, the Woods, father and son, hopped into their car and went out to the club. As they arrived, Nungesser's plane was circling the golf course, and he landed near the first tee. No sooner had he shut off the engine, than a big, red-faced, barrel-chested member in plus fours rushed toward Nungesser waving his driver and shouting:

"This is an outrage! You can't land on the golf course of a private club! You took my wife's eye off the ball! You spoiled her drive!"

Dr. Wood hastened forward and explained to the apoplectic golfer that the flyer was Nungesser—that he had come there by invitation to lunch—that he had shot down sixty-seven German planes—was the greatest of all air heroes. The golfer roared, "I don't give a damn if he shot down five hundred planes! He spoiled my wife's drive!"

Then the steward of the club rushed out shouting, "See here, you can't land here! It's against the rules."

Dr. Wood said mildly, "But he already *has* landed."

"But he can't!"

"But he has!"

"But he can't!"

"But he has! And furthermore he's invited here to luncheon with a member of the club."

"By what member?" demanded the steward. Nungesser fished the name out of his pocket, and the steward looked at it.

"But that man's not a member. He's not a member of the club at all. He only lunches here sometimes with Mr. Jones-Smith."

It began to be apparent that the *garçon charmant* had been in his cups when he invited Nungesser to the Maidstone Club, and had forgotten all about it. So the Woods decided to take

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Nungesser home with them to lunch. In the meantime Dr. Wood, who had been an early member and shareholder in the club, decided that Nungesser ought to have a cup of coffee. The steward reluctantly agreed to let Mr. Nungesser have a cup of coffee. Whereupon Nungesser fumbled in his breast pocket, produced a visiting card the size of a large wedding invitation, but slightly more ornate, and presented it in a courtly manner to the steward. Wood says the card had everything on it but the Eiffel Tower—which is the French equivalent of the kitchen stove.

The steward was embarrassed and unimpressed. When the colored waiter came to serve the coffee, Nungesser produced another and handed it to him. The colored waiter was enchanted and terrifically impressed. The Woods then took Nungesser home to lunch, and later, a bit mystified at the strange ways of Americans, but happy and not out of countenance, he flew back to New York.

Apropos of William Beebe's visit is a tale of the rats in the barrel—and apropos of Father Pigot's, occurs a rhapsodic tribute to Wood's homemade gin.

The barn and outhouses had become infested with rats, and a lot of them were caught alive in basket traps. They were to be loosed as is the custom and killed by terriers. This is not for fun or cruelty, as some imagine, but to train the terriers. In the meantime, Wood dumped the rats in a barrel and observed them with curiosity. He says that they began jumping and that their pink noses came up in waves, like pink bubbles on water, but didn't quite reach the rim. Presently some of them began running wildly around the bottom of the barrel. Soon, like motorcyclists in World's Fair saucers, they were whirling around the sides of the barrel, held by centrifugal force. They ran faster, spiraled up, and finally came hurtling over the rim!

Wood told his naturalist friends. Beebe at first refused to be-

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lieve the story, but was finally convinced. It seemed evident that the rats in rushing and tumbling around over each other at the bottom were occasionally thrown against the wall and discovered that if they ran faster against the curved wall, they were pressed against it and could actually climb out in a spiral. Wood let the rats go for the fun he'd had watching them do it. They recalled to his mind his youthful conquest of the spiral balustrade, he says.

Father Edward F. Pigot, famous Jesuit scientist and seismographic authority, was here from Australia and visited the Woods in prohibition days, soon after the World War. Father Pigot was Irish in origin—and that his association with Dr. Wood was not confined entirely to learned discussions of earthquakes and astronomy is evidenced by the inscription the Reverend Father left in East Hampton:

—a poor, peripatetic star-gazer, late of the Emerald Isle and now from the Southern Cross, who sought in vain in America for some more stimulating beverage than "soft" drink to relieve the fatigue of his midnight vigils—

Beer, stout, brown ale,
Brandy, whiskey, gin?
Quoth the raven,
Nevermore.

Now, however, he at last can say with Archimedes, "Eureka!" And he carries back to Australia, along with grateful recollections, the sample of liquor better than he sought—Wood Spirit!

You may believe, if you choose, that this is merely a metaphorical tribute—but I don't. During prohibition days, Dr. Wood distilled and concocted for his friends and intimates a beverage which still causes the devout to cross themselves fervently. There was always the obvious joke that it was made of "wood" alcohol, but what he put in it remains a partial mystery. Just as the orthodox Moslems have ninety-nine names for Allah, plus an unknown hundredth name, Wood put in seven supposedly known ingredients, but there was a mysteri-

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ous eighth which he refused to reveal. I don't try to guess what it was. The Russians add ether and gunpowder.

Last summer was gay in East Hampton, with friends, guests, the family reunion, while Dr. and Mrs. Wood were preparing a jaunt to California. As usual, it was partly for science and partly for fun. Dr. Wood was going to install one of his big, improved diffraction gratings in the eighteen-inch Schmidt camera telescope on Mount Palomar. If it worked, they'd be wanting an immense one later for the 200-inch monster with its twenty-ton mirror in the other dome. There was a dinner party on the night of their departure. Nobody was in a hurry. Gertrude had the tickets and the money in her handbag. Rob was telling some of his best stories. They caught the train casually, by a couple of minutes' margin.

On the day before they left, I'd noticed a new, mysterious, and strange device. The door of the bedroom occupied by Dr. and Mrs. Wood gives on the living room, and opens outward. This door had been newly fitted with a large and powerful coiled spring. It seemed so queer I had ventured to ask its purpose. Wood pulled the door open, let go, and it shut with a resounding bang. Said he, "It was a birthday present to my wife yesterday. For twenty years she'd been saying to me, '*Will* you shut that door!' "

Then I noticed a small card tacked above, which read:

MANY HAPPY RETURNS OF THE DOOR

At this point Elizabeth Bogert interpolated, "—and the first time it returned, it knocked off mamma's eyeglasses."

If you ask the Wood family today what they think of its celebrated head in connection with some specific scientific achievement or some specific new piece of deviltry, their answers will be brilliant, voluble, and free. If they're feeling at their best—and if it's about anything in particular—you'll get

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all the adjectives and epithets in the thesaurus—sometimes in pride and praise, sometimes filled with a sort of oh-my-god exasperation.

But if you ask the Wood family what they think of him in terms of wider generality, their words fail to flow so freely. He's the head of the clan, he's the husband and father, he's famous, and has their profound respect as well as love. But this doesn't alter the fact that they've got a sort of super Huck Finn in the house, which is perhaps never boring but not always restful. After they'd suffered from one of his pranks last summer, his daughter Margaret (Mrs. Victor White) exclaimed, ". . . my so and so and so and so . . . absurd and ridiculous father!" If you or anybody outside the clan used one of those adjectives about him, I can assure you that this same Margaret, or any of the rest of them, would skin you alive and nail your hide to the barn door.

The "Aunt Sally" who wanted to "adopt and civilize" Huck Finn could be voluble too . . . in particular . . . when it came to any particular thing Huck had done, but not even the genius of Mark Twain could express her feelings toward Huck in general. *They went too deep for words.* When it comes to the Wood family's feelings toward him—they're all in the same boat with Huck's Aunt Sally . . . and so—may I add in conclusion?—is your humble and obedient servant, the author.

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